ALLEN'S
HUMAN ANATOMY.

SECTION II.

BONES AND JOINTS.

LONDON
HENRY KIMPTON 82 HIGH HOLBORN W.C.
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A SYSTEM OF

HUMAN ANATOMY.

INCLUDING ITS

MEDICAL AND SURGICAL RELATIONS.

BY

HARRISON ALLEN, M. D.,

PROFESSOR OF PHYSIOLOGY IN THE UNIVERSITY OF PENNSYLVANIA, ETC., ETC.

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SECTION II.—BONES AND JOINTS.

PROSUNT QUAE OMNIBUS

PHILADELPHIA:
HENRY C. LEA'S SON & CO.
1882.

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ALLEN'S

HUMAN ANATOMY.

BONES AND JOINTS.

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DESCRIPTIVE ANATOMY.

THE BONES.

GENERAL CONSIDERATIONS.

THE skeleton is an assemblage of bones and cartilages joined together to form the framework of the body. Its several parts serve to protect the viscera, and to act as organs of passive locomotion.

A skeleton, as preserved in the cabinet, is said to be *natural* when the bones and cartilages are held in their natural relations by means of ligaments. It is said to be *artificial* when the ligaments have been removed, and wire and leather, or other materials, are substituted for them.

ORIGIN OF BONES.—The bones of the skeleton arise from cartilage for the most part; such are often named, from this fact, *cartilage bones.* Bones not arising from cartilage develop from fibrous tissue; such bones are known as *membrane bones*, since they for the most part appear in membranous expansions. The parietal and frontal bones belong to this group.

CARTILAGES.—The cartilages of the body, while preserving their integrity, aid in resisting shocks and maintaining elasticity. Cartilage is called *permanent* when it presents no tendency to ossification, and *temporary* when it possesses a tendency to turn into bone.

NUMBER OF BONES.—The number of bones in the body varies according to the age of the subject. The number is increased as the several temporary cartilages ossify, and is decreased as the osseous centres unite one with another. Authors do not agree as to the number of bones in the body, since the age at which the bones should be counted has never been agreed upon.

Hyrtl makes the number of bones in the skeleton 240, Leidy, 214, Ward, 206, Quain, 200, Sappey, 198.

In order that intelligent comparison may be made between the numbers above given and the number adopted for this work, the bones are enumerated with some detail in the following order:—

Spine	24
Skull	22
Small bones of the ear	6
Neck (Hyoid)	1
Ribs	24
Sternum	1
Shoulder girdle (including scapulas and clavicles)	4
Superior extremities	60
Sesamoids of same, excluding the pisiforms	4
Pelvic girdle (including the hip-bones, sacrum, and coccyx)	4
Inferior extremities (excluding the patellæ)	58
Sesamoids of lower extremities (including patellæ)	6
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Of these, the occipital bone, sphenoid bone, ethmoid bone, frontal bone, and bones in the skull, and the sternum, hyoid bone, vertebral column, sacrum, and coccyx are unpaired.

The study of the development of the bones will modify the above conclusions both as to number and

symmetry. It may be stated once for all that the facts given are intended to apply to the adult skeleton, and to the purposes of the physician, and not to satisfy the needs of the student of morphology.

CLASSIFICATION OF BONES.

The bones comprising the skeleton are classified either by the region of the body in which the bones occur, as those of the head, chest, extremities, etc., or by the shapes of the bones themselves, when the terms long, flat, irregular bones, etc., are used.

THE LONG BONES.—The long bones are those which resemble for the most part modified cylinders. Hence, they are often called cylindrical bones. They are prismoidal in shape, and slightly twisted. The femur or thigh-bone, the tibia or shin-bone, the fibula or clasp-bone, and the analogous bones in the arm and forearm, are good examples of the class. Long bones of a smaller kind than the foregoing are often classified as the *short* bones. Among these may be placed the clavicles or collar-bones, and the metacarpal and metatarsal bones. They are less prismoidal than the long bones proper. The phalangeal bones, which belong to the same class, are flat on one side, and thus recall the figure of a semicylinder.

Each long bone presents a *shaft* or *diaphysis*, and two *extremities.* The shaft slightly expands to join the extremities. These form the bases of two pyramids, the apices of which may be said to unite in the shaft. In the bones of a prismoidal form the sides of the prism-like figure extend into the extremities, and serve to strengthen them. The extremities of a long bone articulate with the adjacent bones, and ordinarily form what is known as *epiphyseal ends*, owing to the fact that these portions of the bones arise from distinct centres, known as the *epiphyses.* The ligaments are here attached, the muscles have insertions, and the surfaces are marked by rugosities and venous canals.

The end of the bone nearest the body is called the *proximal* end, and that farthest away the *distal* end. When an articular surface is round and convex (especially if it is on the proximal extremity), it is called the *head* of the bone. The *neck* is a contraction placed beneath the articular surface, and is apt to be the narrowest part of the bone. No muscle is inserted either upon the head or the neck of a bone.

FLAT BONES.—The flat bones are irregular and table-like, and ordinarily are passive in their function. Such, for example, are the bones of the skull which protect the brain, and those of the pelvis which protect the internal organs of generation and in part the intestines. An important flat bone, the scapula, is however active in its function.

IRREGULAR BONES.—The irregular bones are of small size, and do not preserve any constant outline. In this class are placed the bones of the carpus and tarsus, and those of the vertebral column. Some are placed in pairs, while others are median and single. They agree in function, however, since they are always found in situations where strength and a slight motion are required. They are thus admirably adapted to sustain weight and to resist shock.

The irregular bones are arranged in a single row as in the vertebral column, or in a number of rows as in the carpus and tarsus, primarily in the longitudinal direction of the limbs, but forming at the same time transverse arches of enormous strength.

SESAMOID BONES.—The sesamoid bones are so named from their resemblance to seeds. They are rounded or oblong ossifications of small size arising in the tendons of muscles, and aid these organs in maintaining accurate relations to articular surfaces. They are thus seen in muscles crossing joints, as the quadriceps femoris and flexor brevis pollicis. They ordinarily possess one or two articular facets.

WORMIAN BONES (OSSA TRIQUETRA).—The Wormian bones are tabular. They are inconstant, of variable size, and are seen nowhere but in the vertex of the skull. They belong to the group of bones here situate, and are firmly articulated with them. They are apt to be seen between the parietal and the occipital bones.

WEIGHT OF THE SKELETON—The skeleton weighs from twelve to fourteen pounds. The right side is somewhat heavier than the left.

TERMS USED IN DESCRIBING BONE.

In the description of bones a number of special terms occur, some consideration of which is necessary to a proper understanding of the text. Among those relating to distinctions among the kinds of elevations or prominences from the common surface of a bone, may be mentioned the following:—

PROCESS.—Any projection from the bone.

CONDYLE.—An articular process of bone, which is

large, and as a rule convex. Upon the tibia, the condylar surfaces are slightly concave.

TUBEROSITY.—A large rounded process.

TROCHANTER.—A tuberosity which serves for muscular attachment in positions favorable to rotatory motion.

SPINE.—A pointed process.

CREST.—A pronounced ridge-like elevation.

LINE.—An elevation less pronounced than a crest.

Every bone presents *surfaces*, *borders*, and *angles*. These terms will frequently recur in the descriptions.

Among the depressions on the general surface of the bone may be mentioned the following:—

FOSSA.—A deep saucer-shaped depression. It may be articular, as the glenoid fossa; or muscular, as the iliac fossa. A *digital depression* is a circular shallow fossa.

GROOVE or SULCUS.—A narrow elongated depression.

FURROW.—A relatively broad, shallow groove.

FISSURE.—A narrow chink. It often answers to lines of defective union between different bones. Fissures are most commonly seen in the skull.

MEATUS.—A sulcus or canal leading to parts other than those defining the meatus. The meatus of the nasal chamber is a depression on the lateral wall of the nasal chamber leading to the pharynx; the external meatus is a tubular passage made up of the squama and tympanic bone, leading to the middle ear.

SINUS.—An open cavity with a narrowed mouth lined with mucous membrane.

The FLEXOR SURFACE and the EXTENSOR SURFACE of a bone are terms often employed in the same sense as *ventral* and *dorsal*. See Definitions in Introduction, p. 20.

The openings in bone are known as—

CANALS.—When they form tubular passages into or through bones.

FORAMINA.—When they form simple openings of transmission.

PROPERTIES OF BONE.—Bone is the firmest and hardest of the tissues, enamel alone excepted, and is especially designed to combine great strength with lightness. Elasticity is one of its most conspicuous properties. The form of the bone aids in maintaining it, as in the rib and the lower jaw; but all the bones possess it in more or less degree. Bone-tissue is either *compact* or *spongy*. When *compact*, it possesses firmness to a high degree, and when *spongy*, lightness. Compact bone is best seen in the lines adapted to bear the greatest resistance and sustain the greatest weight; the spongy is best seen in places where lightness and facility of motion or delicacy of use are the purposes required. Most of the long bones are hollow, and, as already mentioned, are termed cylindrical bones. This form aids greatly in maintaining lightness without sacrificing strength, the wall of the cylinder being composed of compact bone, while the hollow space is filled with a form of fatty tissue (p. 56).

THE CANCELLI.—The extremities of a bone are, on the other hand, solid in the sense of being without a central cavity, and are composed of reticulations of minute plates and rods of bone, which are collectively termed *the cancelli*. The cancellous, or spongy tissue, as it is indifferently termed, is admirably adapted to break the jar of a sudden blow, and to prevent it from reaching the delicate central structures of the body. Each bone exhibits a special arrangement of the cancelli, the one specially adapted to its necessities, and no two bones, or, indeed, no two parts of a single bone, preserve exactly the same arrangement.

In studying cancelli it will be seen that the stoutest laminæ, and the best mechanical disposition for sustaining weight and distributing force exist in the positions where the necessities for such properties are the greatest. As a consequence, it is evident that, while a general resemblance exists between the cancelli of bones of a natural group, as, for example, those of the vertebral column, or the ends of long bones near joints which resemble one another, great contrasts are exhibited in other bones having highly specialized lines of work to perform, such as the astragalus, the calcaneum, and the femur.

Cancelli naturally arrange themselves into those of the articular epiphyses, of the muscular epiphyses, of the ossified articular cartilages, and, in the main, into pillars and laminæ of the shafts of the bones. For convenience these subdivisions are not described separately, although each should be taken up by itself in special studies of any single bone.

The physical properties of bone are capable of being modified by the peculiarities of each of the bones, and will of necessity vary in the performance of different lines of work. The petrous portion of the temporal bone is naturally hard and brittle; the tarsal and carpal bones are spongy, and not inclined to fracture. The former has no superimposed weight to sustain; the latter have important relations to bear while supporting the entire body in the erect position.

The same differences may be noted in the various parts of a single bone. The differences in the relations of the cancelli and the compact matter in this way furnish clews to the significance of delicate mouldings, curves, lines, ridges, or of the general prismoidal or tubular shape of a bone; these are, indeed, so many accessories of structure, and aid the bone in developing to the best advantage its special phases of elasticity, lightness, strength, etc. It would be going too far into the obscure subjects of teleology, the laws of heredity, or the question of primal adaptation of structure to a preconceived design, to pursue this subject further. But this much may with certainty be said, that the general properties of bones, and indirectly their shapes and special uses, are largely determined by traction, pressure, or other familiar expressions of force.[1]

When a sequestrum forms in the cancellous structure, the bone in the vicinity becomes more compact. The sequestrum itself is somewhat more compact toward the centre than toward the periphery.

PECULIARITIES OF THE LIVING OR FRESH BONE.—A bone when examined in its living condition is covered with a membrane called the *periosteum*, which is continuous with the tendons of the muscles inserted into the bone. In a strict sense muscles are inserted into the periosteum of the bone rather than in the bone itself. In the fresh condition the periosteum can with care be raised from the bone. It is thus seen as a thin fibrous membrane of a pearly-white color and firm consistence. In inflammation of the bone the periosteum becomes greatly thickened, and can be detached with ease. The periosteum is not a simple fibrous membrane, as a superficial examination would indicate. While its outer surface is plainly fibrous, its inner surface where it lies in contact with the bone possesses bone-producing power. The importance of a knowledge of these facts in surgical practice cannot be over-estimated.

The ease with which the removal of inflamed periosteum can be accomplished explains the presence of a blood-clot between the periosteum and the bone in the course of ostitis or periostitis. It also accounts for sub-periosteal abscess, and the rapidity with which an abscess of this kind may develop. The special value of the periosteum in aiding and maintaining bone-growth being remembered, the presence of a clot of blood or a layer of pus will be seen to withhold from the bone beneath its normal supply of blood, and the shaft of the bone may die for a distance corresponding to the area of denudation. In this way necrosis of the shaft of bones is explained.

A knowledge of the above conditions enables the surgeon to strip up the membrane from the ends of the bony fragments he wishes to excise without injury to it. It is evident that the detachment of the periosteum must bear some relation to the condition both of the membrane and of the bone itself. The periosteum is more readily detached in growing subjects than in the adult, in chronic inflammation than in acute, and to a greater degree in some bones than in others.

The lower jaw, the clavicle, the bones of the forearm and arm would appear to present in the human subject unusual facilities for denudation, with relatively slight impairment of the vitality of the membrane, if the success attending operation on these bones serves in any way as a standard for comparison. The greater part of the shafts of these bones has been removed, and new bone has formed in its place through the agency of the periosteum. The other bones possess the property in a much less degree,—such as the bones of the lower extremity, and the flat and irregular bones generally. This property appears to be almost entirely absent in the bones of the brain-case.

Bone, while owing much of its genetic power to the periosteum, is not dependent thereon, but is indebted measurably, according to Dr. Alex. Ogston,[1] to the cartilage covering the articular surfaces. In the judgment of this observer articular cartilage is as valuable and necessary in forming and maintaining the structure and shape of bone as is the periosteum. He believes that there is a peculiar structure of the bone in this way produced which permits of its being readily distinguished from that of periosteal origin. "The former variety is marked out," he informs us, "by the main beams or trabeculæ of its mesh-work being placed at right angles to the bone surface, while periosteal bone is characterized either by its main trabeculæ being parallel to the bone surface or by there being no indication of any special direction observable in them at all."

Periosteum may be torn away from the bone to which it is attached by violent injury. In com-

[1] The trabeculæ differ in such slight degrees in different localities that it has been customary to include them in a simple description of each bone. This plan will be pursued in this work. At the same time the student is advised to study the sawed section of bone, for in no other way can the nice points of resistance and pressure as expressed in the details of bony structure be appreciated.

[1] Journ. of Anat. and Phys., 1878, 503. Numerous illustrations.

minuted fracture, portions of bone of variable size are thus denuded, and suffer from atrophy or death in consequence. Mr. Annandale[1] reports an instance in which the periosteum had been stripped from the patella in a case of rupture of the patellar ligament. In some forms of dislocation an analogous lesion occurs; such, for example, is the elevation of the strong layer of periosteum covering the posterior surface of the sternum in displacements of the manubrium upon the gladiolus,—the lower end of the former lying behind the upper end of the latter.[2]

MEDULLA.—The interior of the bone is occupied by a peculiar fatty substance which has received the name of the *medulla.* The membranous surfaces of the medulla, which lie in contact with the bone, have been often spoken of collectively as the *endosteum*, although such a membrane cannot be separated from the medulla. The spongy ends of the long bones, and the interior of the flat and irregular bones, do not possess the fatty medulla, but in its place there is a reddish flesh-like substance occupying the interstices of the cancelli, which, under the microscope, resolves itself into large nucleated cells. It is from this tissue that the fatty medulla has originated, since we find in the bones of the infant that the medullary cavity and the fatty medulla are absent, and that their places are occupied by the same tissue which is seen throughout late childhood and adult life in the extremities alone.

FRESH BONE.—The *fresh bone* is found to be of a faint yellowish-pink or bluish yellow color, the degree of bluish tinge being determined by the condition of the circulation at the time of the death of the individual. In deaths from drowning, or in analogous states in which the blood has become largely surcharged with carbonic acid, the bones are bluer than in deaths from other causes. The yellow color is due to the effect of the presence of the fluids in the body and the fatty medulla upon the white color of the osseous tissue. Bones of the young subject are more uniformly red than those of the adult.

DRY BONE.—When the blood, fat, membrane, and cartilage are removed from a bone, as, for example, by maceration, the color becomes white. In this condition the bone is porous. All the interstices and the canals leading thereto are freely continuous with one another; the bone thus absorbs fluid readily, and will permit a column of mercury to pass through it as through a sieve, from end to end.

The outer surface of the well-developed long bone, as the femur and humerus, is found to be marked by minute elevations, with intervening linear depressions, while here and there over the surface of the bone are small, flat, whelk-like nodules.

The surfaces are also pitted by innumerable minute orifices for bloodvessels, and near the extremities by larger ones (mostly for veins) opening from the bottom of the large depressions there present. The main nutritive canal of the long bone enters in some part of the shaft, and passes obliquely into the medullary cavity. The direction of this canal varies in the different bones. In the ulna, radius, and femur it is directed upward; and in the tibia and humerus it is directed downwards.

The dry bone, when exposed for a long time to the atmosphere, splits into laminæ. It is thus proved that the osseous tissue is laminated, and not homogeneous in structure.

CHEMICAL ANALYSIS.—Bone when subjected to chemical analysis yields:[1]—

Calcium carbonate	7.05
Magnesium phosphate	2.08
Calcium phosphate	58.39
Calcium fluoride	2.25
Organic matter	30.23
	100.00

Thus nearly one-third of the component parts of bone is composed of organic, and the remaining two-thirds of inorganic substances.

If bone be subjected to the prolonged action of an acid,[2] the inorganic substances are dissolved, leaving the organic unchanged. The form of the bone by this procedure is preserved, but its consistence is fibrous merely, and its strength and rigidity are lost. Such a specimen can be bent in any position by moderate force, and in the case of the fibula can be even tied in a knot.

If, on the other hand, the organic portions be removed, by subjecting a bone to the action of fire (as in a furnace), the organic matters are destroyed by burning, and the inorganic portions only are left. The form of the bone, as in the other procedure, is

[1] Edinburgh Med. Journal, 1875, 838.

[2] W. Rivington, Med. Chir. Trans., lvii. 102.

[1] Gorup-Besanez. Anleitung zur Qualitativen und Quantitativen Zoochemischen Analyse, 1871, 420.

[2] For this purpose a solution of hydrochloric acid in water may be prepared, having a strength of one part of acid to sixteen of water. The fluid should be renewed daily.

preserved, but the elasticity and the toughness are destroyed. The bone is thereby made preternaturally brittle, since it is composed entirely of bone-salts and ash.

The living bone with a deficiency of organic material is thus too brittle, as one with a deficiency of inorganic material is too yielding. The mean between these extremes results in the normal property of bone. This mean varies, however, according to age. The bone of the infant, with its want of medullary canal and small proportion of bone-salts, while admirably adapted to a state of development, would be the source of serious disadvantage in the adolescent or adult. In old age the bones become more brittle, owing to the loss they sustain in a diminution of their organic materials.

IDENTIFICATION OF BONES FOR MEDICO-LEGAL PURPOSES.

Courts of justice not infrequently demand expert testimony upon the nature of bony fragments submitted to examination, or upon the presumed peculiarities of the missing portions. Are the bones human? Do they belong to one individual? What was the sex, age, or height of the individual? Are the bones healthy or diseased? Do they show the effect of previous, recent, or old injury? Can the time since death be determined by examination of the fragments?

The propositions embraced in such questions necessarily involve many difficulties, most of which, however, can be readily overcome. In most cases special study of the suspected part can alone be relied upon in arriving at a decision, since the individual variations of bones prevent the following of fixed rules, no matter how carefully they may have been prepared.

The bones of the opposite sides of the body, while bearing a close resemblance to one another in general shape and in the relative development of the details of structure, will be often of different lengths. This fact, which tailors and shoemakers have observed from time immemorial, has awakened of late years professional interest.

Dr. Wm. Hunt[1] called attention to the fact that in the human body the lower limbs are of different lengths. According to the measurements of Dr. W. C. Cox,[1] this difference exhibits a range of from one-eighth to one-half of an inch. Dr. J. S. Wight,[2] in a subsequent series of observations, arrived at similar conclusions. Dr. Jeffries Wyman[3] had previously determined that the clavicles and ulnas differ in length.

In endeavoring to determine the sex of the individual, it must be borne in mind that the pelvis is the most characteristic portion of the skeleton, and that the difficulty of determining the point is rendered greater both before and after the child-bearing period. The well-known differences between the male and the female pelvis need not be repeated here. It will be observed that the bones of the female are smoother, smaller, and more delicate than the corresponding bones of the male. According to Sappey, the skull of the female is longer as compared to its breadth and height than is that of the male. The manubrium of the sternum in the female, according to Hyrtl, exceeds in length that of half the body of the bone; while in the sternum of the male the body is at least twice as long as the manubrium. Dr. Thomas Dwight[4] showed that this rule, like most of its kind, is open to many objections. Yet one-half of the specimens measured by this observer confirmed the statements of Hyrtl.

The bones of young subjects may be distinguished by the epiphyses remaining ununited with the shafts. The surface of the bone in contact with periosteum is less smooth than in the adult, and may present the appearance of the periosteum having been violently detached. The vascular openings are relatively large and numerous. The jaws are more or less occupied by developing teeth. Bones from an aged individual are either thinner or thicker than in the young adult. The outer wall of the orbito-temporal septum is thin and often diaphanous. The depressions in the bones of the cranial vertex for the Pacchionian bodies are deeper.

With regard to the readjusting of detached portions of a skeleton Meyer gives the following rule for placing the pelvis in its approximately correct position: Bring the anterior superior spines of the ilia and the spines of the pubes into the same vertical plane. This writer finds that a line running from the upper surface of the symphysis pubis to the transverse depression in the third sacral vertebra will form an

[1] Phila. Med. Times, Jan. 16, 1875; also Am. Journ. Med. Sci., Jan. 1879, 102.

[1] Am. Journ. Med. Sci., April, 1875, 438.

[2] Archives of Clinical Surgery, Feb. 1877, 283; Proc. Med. Soc. County of Kings, N. Y., Jan. 1878, 338.

[3] Proc. Boston Nat. Hist. Soc. xi., 1868, 246.

[4] The Identification of the Human Skeleton: a medico-legal study. Mass. Med. Soc. prize essay for 1878. Boston, 1878.

angle of 30° with the horizon nearly. According to Dwight (loc. cit.) the only objection to this rule is the exceptional fact that some subjects possess more than the normal number of vertebræ.

The point of the coccyx is usually a trifle above the lower border of the symphysis pubis.

In the female the centre of the body is at the symphysis pubis; though in women above the average height the centre is slightly above this point, and in those below the average slightly below it. In the male the centre is in average examples a little below the symphysis, but it is subject to some variations, as in the female.

In readjusting the dry or macerated bones of the limbs with the view of ascertaining the height of the individual, one-quarter of an inch must be allowed for the cartilages of the knee; one-eighth of an inch for the cartilages of encrustment of the astragalus and calcaneum; one-half of an inch for the remaining portions of the foot; and one-eighth of an inch for the joint between the occipital condyles and the atlas.

For further information on the above and allied topics the reader is referred to Dr. Dwight's valuable essay, previously quoted, from which the writer has freely copied and epitomized.

With reference to the question whether the bones are diseased, the same difficulties obtain as in studying the healthy bones. The lines of former fracture may be confounded with variation of the normal structure. The normal details of healthy nutrition may so resemble the products of inflammatory processes as not to be with certainty distinguished; while defects of development may be confounded with post-natal atrophic changes.

Nevertheless careful comparisons will greatly assist in determining these and other distinctions. In the specimen suspected of having sustained fracture the part should be carefully macerated, since some instances of alleged atrophic or diseased change (as for example in the neck of the femur) have been shown by this means to be old ununited fracture. Lines of exostosis or inflammatory outgrowth can be distinguished from the lines of union of fracture by making a section of the bone. If at any time the bone has been fractured the evidence of the old lesion will be seen in the interior as well as upon the surface; while, if it has never been so injured, the evidences of change are apt to be superficial, and even if deeply seated show increased thickness and density of the bone-tissue.

Exposed surfaces of healthy adult bone, more particularly those of the long bones, exhibit innumerable minute linear depressions which serve to maintain the periosteum in position. These are sometimes supplanted in bones of muscular individuals by sparsely distributed elliptical nodules (see p. 101). In chronic peripheral inflammation these linear depressions are exaggerated in depth, and the spaces between them are apt to form minute, irregular eminences. In extreme examples of the results of formative inflammatory change such eminences may be confounded with the hyperostosed condition following chronic periostitis. In bones showing the least sign of atrophic change the condition opposite to the above is seen to exist. The linear depressions disappear, and the bone is everywhere smooth. Occurring at inconstant and variable intervals are minute openings which can be distinguished from the orifices of vascular canals by their being neither oblique nor crater-shaped, but having sharp-cut edges on the level of the bone surfaces as though punched out with a cutting instrument.

A knowledge of the development of bone is essential to a correct understanding of some morbid processes. Thus the manner in which a bone will be affected by disease is oftentimes the same as that in which it was developed. The relations between the epiphysis and the shaft of a long bone will have to be remembered by the surgeon. The epiphysis may separate spontaneously in some diseases and injuries. In fracture of the neck of the femur, that portion of the neck attached to the epiphysis may become absorbed, thus restoring to the epiphysis its original contour. In chronic arthritis, a series of characteristic appearances are restricted to a line near to or lying within the epiphysis. A sequestrum may be commonly restricted to a shaft, or, rarely, to an epiphysis.[1] Disease of an epiphysis can affect the adjacent shaft as on the other hand disease of a shaft can affect the adjacent epiphysis. Many diseases of the joints have their origin in contiguous epiphyses.

The restriction of morbid processes to portions of bone which are distinct from the point of view of development, is well illustrated in the superior maxilla (*q. v.*).[2]

In the composition of the complex association of bones, such as those of the skull or sacrum, certain surfaces are found remaining free from contact with one another. These ordinarily afford transit to important nerves and vessels. In the instance of the

[1] Brodie, Surg. Lectures, 222, and Adams, Trans. Path. Soc. Lond., iii. 165, and Birnett, Ibid. vi. 288. Cat. to Mus. Guy's Hosp. No. 1484, 49.

[2] See also a paper by the author on Localization of Diseased Action in the Osseous System, Am. Journ. Med. Sci., July, 1870, 404.

thyroid or obturator foramen in the innominate bone, the opening is closed by membrane, which, however, is pierced for the passage of a small nerve and artery. The development of the more complex single cranial bones, such as the temporal and sphenoid, explains the apparent anomaly of nerves and bloodvessels piercing resistant bony walls. Each vessel and nerve will be found to lie between the several elements composing the bone, or in a foramen or canal near the margin of the several component parts. Thus the facial nerve, in its intricate passage through the temporal bone, passes *between* the parts making up the embryonic temporal bone. The branches of the fifth cranial nerve pass through the *margin* of bones near the primary interspace between distinct embryonic portions of the sphenoid bone. In young subjects the foramina isolating the different branches of a nerve are imperfect, and in some animals they have no separate existence. It is rare for a nerve to pierce a bone, as a small branch is sometimes seen perforating the clavicle, or a nerve and artery passing through a foramen above the epitrochlear process of the humerus.

REMARKS.

Bones as Mechanical Agents.—The student is especially urged to examine the bones as mechanical agents. He should constantly seek for the conditions which underlie or (not to speak too boldly) create the ossific forms. Thus, in studying the bones of the face, he should observe that the ascending nasal process of the superior maxilla is stout in order that it should receive and distribute the force of the occlusion of the lower maxilla against the upper; while the lachrymal bone immediately behind it is thin and weak, since none of the same or similar labor is exacted of it. Likewise, in the innominate bone the prismatic elevation extending from the sacro-iliac symphysis to the acetabulum comprises the most massive portion of the bone, since it is the supporter of the sacrum and indirectly of the superimposed vertebræ; while the bone on either side of the thickening (often so thin as to be translucent) possesses little or no strength.

Variations in the Shapes of Bones.—Variations in the form of bones are due to alteration of (1) blood-supply, and (2) the strength of muscular attachments.

(1) In studying the varieties of form due to blood supply, it must be remembered that the needs of the tissues determine the quantity of blood going to them. Hence, variations with a tendency to excess of size are found in locations showing the greatest functional activity, while variations of reduction of size are seen in locations of diminished activity. For instance, the variations in the form of the atlas are of two kinds—those in which the lateral portions of the bone are larger than usual, and those in which the median portion of the bone is smaller than usual. The former is explained by the fact that increased functional activity has led to increased vascular supply; and the latter by the fact that the retarded activity has led to diminished vascular supply.

The direction by which arteries enter the long bones will be seen to determine the degree of vascularity at the ends thereof. Thus the nutrient vessel of the shaft of the femur being directed upward, congestion of the medulla is more apt to occur at the proximal than at the distal part of the bone. The nutrient vessel of the tibia, running as it does downward, will tend to fix the position of congestive change at the distal end of the bone. After fracture of a long bone, the portion remote from the main source of blood-supply may undergo atrophy.—Epiphyses are very vascular, as compared to the shafts of bones, and, all things being equal, the longer the period of separation of an epiphysis from its shaft during development the longer is the vascularity of the epiphysis sustained, and therefore the greater the liability it incurs to the invasion of disease.

(2) The lines of tendinous insertion of muscles of the limbs often modify the surfaces upon which they appear, and serve as boundaries of topographical divisions of the bones. This is conspicuous in the humerus, ulna, femur, tibia, and fibula. In the last two bones, the lines fixing the interosseous membrane—itself an intermuscular septum—separate the anterior from the posterior surfaces. The linea aspera of the femur is exclusively a ridge of muscular significance, and is determined by the fibres of the tendons of the adductor and extensor muscles here aggregated.—The lines of exaggerations of growth seen in bones are apt to be associated with the relations of the fleshy parts. They oftentimes constitute the minor degrees of difference between bones of individuals, and even between the corresponding bones on the opposite sides of the same individual. They give, in addition, the best clue to causes for location of morbid growths, particularly the exostoses. The exostoses often existing in the line of the condylar insertion of the Adductor Magnus muscle (the "rider's bone"), as well as the osteophyses along the lines of intermuscular septa at the lower part of the fibula, are of this significance.

In muscular subjects the humerus is often obscurely angulated at the part at which the Deltoid muscle is attached. This is sometimes so pronounced as to form a variety in the shape of the bone. In other bones the surface of origin for the third head of the Triceps muscle is convex instead of flat, and gives the bone the appearance of being bowed forwards. If such a specimen be laid upon a plane surface, the distal end of the bone will not touch the plane—the bone resting upon the head and the centre of the above-named tricipital surface.—Specimens of chronic ostitis of the humerus are not rare in which the disease has been confined to this portion of the humerus.—On the other hand, an osseous surface is sometimes seen covered

by a broad smooth muscle, and is in this way protected from the tendency to excessive growth elsewhere evident. The impression of the Temporal muscle is rarely the seat of diseased action of any kind. In some remarkable examples on record of diffused cranio-facial exostosis the temporal regions are entirely free from disease.[1]

Many processes of bone are created, as it were, by muscular traction. Thus the pterygoid process of the sphenoid bone has no existence in animals, whose muscles for moving the lower jaw are disposed in a manner different from those of man and mammals. The massive mastoid process is absent when the Sterno-Cleido-Mastoid muscle is also absent, as in most quadrupeds. The femur of some animals, such as the rhinoceros, possesses three trochanters. Two of these correspond with those found in man. The third is for the insertion of muscular slips not found in man, except as anomalies. It can be said, indeed, that the trochanters in the human femur are correlative with the muscles inserted into them. In the absence of the muscles the processes would never have appeared.

The effect of muscular action in modifying the shapes of bones has formed the subject of special study by Prof. Henry J. Bigelow.[2] According to this writer, the inter-trochanteric ridge of the femur is simply a buttress erected for the insertion of muscles upon and over the true neck, which is represented by a more deeply-seated septum or layer of compact tissue (see Femur). Dr. Thomas Dwight[3] detects similar superficial deposits of bone beneath the anterior inter-trochanteric ridge, and sometimes under the coronoid process of the ulna and the tubercle of the radius.

Muscular Action as a Cause of Ostitis and Necrosis.—Diseased processes may be excited through muscular action. Necrosis has been known to follow ostitis, the result of prolonged traction of a muscle upon the bone yielding its points of insertion. Prof. Syme,[4] in commenting upon a case of sinus of the hip depending upon exfoliation from the pelvis, states that the patient had first experienced uneasiness after a day's employment in curing herrings, and that the discharge of his duty had required him to stand with his feet apart, alternately stooping and stretching his arms upwards to the full extent; subsequently to which he had felt a painful sense of fatigue in the back part of the thighs. It then occurred to the author that the disease had originated from over-exertion of the muscles which arise from the tuberosity of the ischium, and that the bone with which they are there connected had suffered in consequence so as to exfoliate instead of being excited to preternatural growth, as Sir Astley Cooper with apparent good reason thought likely to happen from inordinate muscular contraction. It seemed evident enough that injuries similar to the foregoing cannot result from the direct effect of violence, since in all the cases detailed the bone concerned was securely protected by its situation from any such injury. In all of them there was violent muscular contraction, and it seems probable that this may have been the exciting cause of inflammation and death of the bone.

The Shapes of Bones as Modified by Diseased Action.—Bones serve as resistant masses to the superincumbent weight of the body. In rickets and other diseases which tend to soften the bones, characteristic deformities are found to result from the bones yielding to the weight of the tissues.

The base of the skull may become flattened from the weight of the brain, and the bones of the vertex distended and distorted from pressure from within. The bones of the lower extremities from analogous causes become bent. In the long bones which have undergone softening, but which have regained their former toughness and rigidity, strong ridges are observed upon the concave aspects of the curve; and this superabundant bone, according to Stanley,[1] is placed exactly where the curvature of the bones renders them mechanically weaker, and where, consequently, their greatest waste of tissue occurs. This compensative arrangement is called by Stanley reparative hypertrophy.

Bone may also be altered in form by pressure which has been long maintained against it. An aneurism in an artery lying upon a bony surface will cause the absorption of the bone at the place of greatest pressure. Thus aneurism of the ascending aorta will create absorption of the sternum or ribs; and aneurism of the descending aorta, of the bodies of the vertebræ. Tumors of other kinds will in the same way cause bone to yield; tumors of the tongue will create deformation of the jaws, and tumors in the nose and pharynx will press upon and destroy the bones of the nasal region. One of the most remarkable instances of this pressure seen in the latter locality is reported by Hilton,[2] in which an osseous tumor of the left side of the face had distended the superior maxilla and adjacent structures to a remarkable extent. The mass subsequently underwent spontaneous evulsion, but the deformity created by its former presence persisted, in addition to which a cavity communicating with the enlarged nostril remained.—An hydatid tumor placed between the left lung and the diaphragm has been known to cause absorption of the bodies of the vertebræ and to permit intrusion of the hydatids into the vertebral canal. This intrusion occurring suddenly gave rise to the impression that hemorrhage had occurred in the spinal cord.—Even the petrous portions of the temporal bone will not long resist contact with a tumor much less compact than itself. Dr. Morris Longstreth,[3] in dissecting the relations of a sarcoma

[1] H. Lebert. Traité d'Anat. Pathol. 1857. Atlas, pl. xxxii. Murchison, Trans. Path. Soc. London, xvii. 243, pl. 10.

[2] The Hip, 1869, 125.

[3] Journ. Anat. and Phys., 1875, 311.

[4] Ed. Med. and Surg. Journ., 1828, contains Syme's original notice of this subject.

[1] Illustrations of the Effects of Disease and Injury of the Bones. London, 1849, pl. xx. p. 22.

[2] Guy's Hosp. Rep., i., 1836, 493.

[3] Burnett's Treatise on the Ear, 555.

which had originated in the left cerebellar hemisphere, and had sent a portion of its mass within the internal auditory meatus, noticed that the bony canal was much widened and funnel-shaped. In a case reported by Bœttcher[1] the tumor had dilated the canal in all directions.

Interstitial absorption from undue pressure plays an important part in the causation of deformity of the spine, in which condition bodies of the vertebræ become changed in outline—sometimes to a remarkable extent—not from any primary diseased action therein, but from long-continued vicious pressure. The question of prognosis in all cases of spinal deformity must be wisely based upon what is known of the deformed shapes of the vertebræ entirely apart from the question of removal of the original exciting cause.

Bones, in addition to the modifications of their surfaces due to the origin and insertion of muscles, may be changed in form at certain localities by tendons and bloodvessels. The tendon of the Obturator Internus, as it lies over the innominate bone above the tuberosity of the ischium (creating grooves even in the normal bone), will cause deeper and broader grooves to appear in bones which are preternaturally softened. In a skeleton of a giant, preserved in the Mütter Museum in Philadelphia, the exaggeration in these grooves is well represented.

In like manner the points of origin and insertion of muscles will cause in young bones, or in those of the character above described, the opposite effect, and will create shallow depressions upon the surface of the bone instead of prominences.

THE VERTEBRÆ.

General Considerations.

Every vertebra, excepting the atlas, is composed essentially of three parts, viz., a body, and two lateral portions.[2] The body defines the vertebral canal in front, and the lateral portions at the sides and behind. Each lateral portion arises from the posterior outer margin of the body, and passes for a short distance outward and backward. It is thence abruptly deflected inward and backward, and joins its fellow of the opposite side to form at the point of contact *the spinous process* or *spine.* The union of the lateral portions constitutes *the vertebral arch.* The figure of the vertebral foramen thus determined by the convergence of the lateral portions is triangular, and presents one posterior and two lateral subrounded angles.—The vertebral canal accommodates the spinal cord and membranes; the spinal nerves, as they pass from their apparent origin in the spinal cord to their points of exit from the vertebral canal; the vertebral artery on its way from the vertebral foramen of the atlas to enter the foramen magnum; and the lymph-space between the membranes.[1]

The cancelli.—The lines of cancelli in the vertebræ are arranged in three series. The first consists of longitudinal concave lines with their concavities directed forward. The second resembles the foregoing, but the concavities are directed backward. The third series are transverse,—the upper lines being concentric to the superior, and the lower to the inferior articular surface.

The other general features of a vertebra are the following:—

The *pedicle*, which is that rounded part of the lateral portion lying between the body and the lateral angle; the *lamina*, the thin, flattened part lying between the lateral angle and the spine,—it is seen to be vertically compressed at its base; the *superior oblique or articular process* lying at the base of the pedicle,—it presents an articular facet looking backward; the *inferior oblique or articular process* lying upon the base of the lamina at the angle,—it presents an articular facet looking forward; *the inferior notch* lying beneath the pedicle, and between the body of the vertebra and the lamina; and the smaller *superior notch*—a less constant feature—lying upon the pedicle between the body and the superior articular process.—In articulation the apposition of a pair of superior and inferior notches constitutes an *intervertebral foramen* for the exit of a spinal nerve.

THE VERTEBRAL COLUMN.

The vertebral column is the figure resultant upon the apposition of the vertebræ in natural order. It is usually accepted to include the sacrum and coccyx. But for practical purposes nothing is gained by thus

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[1] Archiv Oph. and Otol., iii. 134.

[2] The atlas, while defining the vertebral canal in common with the other vertebræ, is composed of two lateral portions only, and is technically without a body.

[1] The vertebral canal varies greatly at different parts of the column. According to Humphry, the antero-posterior diameter, within the axis, is but $\frac{6}{8}$ of an inch; from this it gradually diminishes to $\frac{5}{8}$ of an inch at the middle of the dorsal region. Opposite the last lumbar vertebra it increases to $\frac{7}{8}$ of an inch, and thence rapidly diminishes until the sacrum is reached. The frontal diameter at the atlas measures $1\frac{1}{2}$ inch, at the axis 1 inch, at the second dorsal vertebra $\frac{6}{8}$ of an inch, at the last $\frac{7}{8}$ of an inch, and at the lumbar vertebræ 1 inch.

uniting these parts, since special descriptions and entirely distinctive relations are required properly to elucidate them. Omitting, therefore, the sacrum and coccyx, the vertebral column is composed of—

7 cervical vertebræ,
12 dorsal vertebræ,
5 lumbar vertebræ,

making a total of 24 bones.

The vertebral column is best studied when the intervertebral disks, ligaments, and articulations are in position. By this union of the separate bones, the intervertebral notches become connected into intervertebral foramina; the various segments of the vertebral canal join with one another; the facets for articulation of the ribs become complete sockets; and the space in each bone between the spinous and the transverse processes extending the entire length of the spine,[1] becomes known as the vertebral groove.

As a whole, the vertebral column protects the contents of the vertebral canal, affords attachments to important muscles, and supports the head, while guarding it from shock. It serves in front to protect the viscera, and in an indirect manner to furnish points of attachment to structures holding the viscera in position. Thus the descending aorta is firmly fixed to the spine along its entire course,—and from and about it the mesenteric and other peritoneal folds arise.

The vertebral column increases in size from above downward, and may be said to rest upon the sacrum by the massive bodies of the lumbar vertebræ. Its form, therefore, is pyramidal, but this form is much modified by the presence or absence of ribs as well as by surfaces for ligamentous and muscular attachments. Its *length* is about one-third that of the body.

Mechanics of the Vertebral Column.—The mechanics of the vertebral column embraces three distinct subjects:—

(1) The adaptation of the vertebræ to support the head.
(2) The degree of motion present between the vertebræ.
(3) The production of spinal curvatures.

(1) *The adaptation of the vertebræ to support the head.*—The head rests directly upon the lateral portions of the atlas. The weight is thence conveyed through the superior articular processes to the bodies of the vertebral column, but a portion is sent to the lateral masses of the remaining cervical vertebræ as well, and through them to the bodies of the dorsal and lumbar vertebræ. There are thus two lines of weight in the vertebral column: one direct through the superior articular facets of the axis to the bodies; and another passing from the same point downward through the columniform articular region of the cervical vertebræ to the dorsal region, whence it again passes to the bodies, which now sustain the weight of the superincumbent mass.

The shape of the spine directly assists in sustaining the weight of the head. According to F. O. Ward,[1] the lumbar region—the most massive—contributes seven parts to the column; the dorsal, eleven; and the cervical, five. The lumbar and nine lower dorsal vertebræ form a pyramid whose base rests on the sacrum. The six lower cervical vertebræ form another pyramid, whose base rests on the first dorsal, and whose apex is surmounted by the atlas on which again is balanced the globe of the cranium. Between these two pyramids, and extending from the base of the upper to the apex of the lower, intervene the three superior dorsal vertebræ, which constitute a third, but inverted pyramid. Thus, though the whole column presents a cone whose base is somewhat more than double the diameter of the apex, yet this main pyramid is composed of three subordinate pyramids. It is evident from this disposition of parts that a structure of enormous strength arises well adapted to the special demands made upon it.

(2) *The degree of motion present between the vertebræ.*—The articular processes are also of great importance in the mechanics of the vertebral column. The motion between the articular surfaces is greater in the cervical than in either the dorsal or the lumbar region. On the whole it may be said to become less in regular degree from above downward. In the lumbar region the inferior articular processes are in a measure embraced by the superior. In the dorsal region the surfaces are simply apposed, but the motion between them is impaired by the imbrication of the dorsal spines and the manner of articulation of the ribs.

(3) *The production of spinal curvatures.*—The weight of the body above, and the traction of muscles at the sides, cause the vertebral column to assume a number of curvatures. These modify the shapes of the bones, and enable them to best accommodate themselves to the forces mentioned. The peculiarities of shape of the bodies, the intervertebral

[1] It will be noticed that the words "spine" and "vertebral column" are used synonymously, as are the words "spine" and "spinous process."

[1] Outlines of Human Osteology, 18.

disks, the articular processes, etc., are all moulded to one another, as a series of effects, by the kinds of pressure and traction to which they have been and are subjected. To such an extent, indeed, is this the case that the curvatures remain after the spine has been detached from its surroundings.

The antero-posterior curvatures.—The main curvatures are antero-posterior, and are three in number —the *cervical*, the *dorsal*, and the *lumbar*. The first presents a convexity forward; the second, backward; and the third, forward. The figure of the spine is thus sinuous.

Humphry[1] has accurately defined the curves of the spine to be as follows: The first or cervical curve begins at the top of the odontoid process, and terminates at the middle of the second dorsal vertebra. It has its convexity in front, and forms 18° of a circle whose radius measures 6⅝ inches; the most prominent point anteriorly is the forepart of the body of the fourth cervical vertebra.—The second or thoracic curve begins at the middle of the second, and terminates at the middle of the last dorsal vertebra. It has its concavity forwards, and forms 42° of a circle, whose radius measures 12⅞ inches; the most prominent point posteriorly is the hinder edge of the body of the seventh or eighth vertebra.—The third or lumbar curve, beginning at the middle of the last dorsal, terminates at the lower and anterior edge of the last lumbar vertebra. It is convex anteriorly, and forms 80° of a circle, whose radius is 5⅜ inches.—The fourth or pelvic curve, sharper than either of the others, begins at the upper edge of the sacrum, and terminates at the top of the coccyx. It forms 125° of a circle, whose radius is 2⅝ inches. The degree of curvature is not uniform, but is greatest a little below the middle.

The relation of weight to curvatures.—A direct line from the superincumbent weight at the head passes through the odontoid process and points of confluence of spinal curves, and falls a little in front of the promontory of the sacrum. This line passes through the points at which the vertebral curves run into and support each other. Lying in advance of the bodies of the fifth to the ninth dorsal vertebræ inclusive, it leaves a larger portion of the dorsal curve behind the line of gravitation than is the case in the cervical and lumbar regions. In the stooping position the line falls further in front of the one above indicated.

The curves are most pronounced in persons who have the greatest degree of normal exercise of the body, as in savages, and in those whose occupations accustom them to carry weights on the head. On the other hand, they are defective in persons of a sedentary habit and in bed-ridden invalids.

The curves are liable to change when the position of the weight is shifted. In forced stooping the lumbar curve is obliterated and actually slightly reversed. In the sitting position the hollow of the spine at the lumbar region disappears.

Lateral curvatures.—The existence of normal lateral curvatures in the spine has been a subject of some difference of opinion among anatomists. Dods, in 1824, appears to have been the first clinical writer accurately to define the condition. Quain, Humphry, and Ward among systematic writers describe a slight degree of lateral curvature as observable in most cases in the dorsal region. Its convexity is directed to the right—a result due presumably to the greater use made of the right than of the left arm. According to Beclard, a curvature is exhibited to the opposite side in left-handed persons. This statement is disputed by Adams,[1] who doubts the existence of lateral curvature as a physiological condition.

That such a curvature, however it may be classified, is dependent upon muscular action has been generally maintained by observers, who are inclined to accept the kind of explanation presented by Quain as applicable to all examples. Lateral curvature is never seen, according to Sayre,[2] in vigorous subjects who are habituated to carrying weights on the head; since both right and left groups of the muscles of the spine are here equally exerted. If a lateral curvature is developed in the dorsal region, which is commonly the case, a secondary compensatory curve in the opposite direction is developed in the loin.

Lateral curvature may also follow upon the insufficient support given the entire trunk by inequality in the lengths of the lower limbs. In cases where one limb is much shorter than the other, as in fracture of one of the bones of the lower extremity followed by much shortening (or in paralysis or insufficient development), the side of the pelvis answering to the shortened limb falls, and a compensatory lateral deviation of the spine from the normal line always ensues.

Lateral curvature with rotation.—Humphry[3] noticed, as early as 1850, that in lateral curvature the motion is not simply of a lateral character, nor

[1] The Human Skeleton, 147.

[1] See p. 109.

[2] Spinal Disease and Curvature, 92.

[3] L. c., 171.

one strictly confined to the sides of the bodies, but that the hinder parts of the sides, or the points of confluence of the arches and bodies, are involved, viz., at the points at which the vertebræ remain cartilaginous after the rest of the bodies and arches have become ossified. It is certainly suggestive that these curvatures are common in young growing persons. In consequence of the above-named parts yielding, the bodies become twisted or *rotated* a little to the opposite side. This writer calls the motion thus described the vertebral twist, and states that it is an almost constant accompaniment of lateral curvature. A. B. Judson[1] has also arrived at the conclusion that a rotatory motion of the bodies of the vertebræ is present in lateral curvature, and, indeed, initiates the movement. His theorem, which is stated independently of Humphry's, and varies therefrom, is based upon the fact that the posterior portion of the vertebral column, being a part of the relatively fixed dorsal parietes of the chest and abdomen, is confined to the median line of the trunk; while the anterior portion, projecting as it does into the thoracic and abdominal chambers, and being devoid of lateral attachments, is at liberty to move to the right and left of the median line. By means of an appropriate apparatus, this observer induces lateral curvature with rotation of the vertebræ by vertical pressure received upon the summit of a vertebral column whose base is fixed. Double curvature with rotation in each curve may be produced by confining one of the dorsal vertebræ at the same time that pressure is exerted from above. These experiments appear to have been made on an artificial preparation of the spine, without ligaments. They need repetition on a trunk with ligaments, muscles, ribs, diaphragm, and liver in place before the results can be accepted.—The rotatory motion is freer at the upper part of the dorsal region than elsewhere, being slight in the neck, and absent in the loin and its transition to the dorsal region.

According to W. Adams,[2] "The articular processes undergo very important structural changes at an early period of the formation of lateral curvature. The articular facets become altered in their direction and aspects, according to the extent of the lateral deviations of the bodies of the vertebræ—thus increasing in degree of alteration in proportion to the severity of the case. In the lumbar region where these articular processes are naturally nearly vertical in direction—looking inwards and outwards respectively—they gradually assume in a severe case of lateral curvature a very oblique direction. In lateral curvature with rotation, the transverse processes are depressed towards the abdominal cavity, and, in severe cases, cannot be felt by external examination; whilst those on the convexity of the curve project backwards towards the skin, and may even rise to the level of the apices of the spinous processes, and be readily felt along the outer margin of spinal muscles, which they also protrude backward and are rendered prominent. This deviation in the direction of the transverse processes is extremely important in a diagnostic point of view, and will enable the observer to diagnose a curvature in the lumbar region in cases in which no lateral deviation of the spinous processes exists."

[1] Trans. N. Y. Acad. of Med., 1876, 315. Literature.

[2] W. Adams, Med. Times and Gazette, Dec. 7, 1861, 574.

THE INTERVERTEBRAL FORAMINA.—The intervertebral foramina vary in different regions. They are more forward in the neck, where they are small and round, than in the loins.

THE SPINES.—The spines are arranged in accordance with their degrees of motility. They are directed either horizontally backward or slightly downward in the neck and loins—but downward and backward in the dorsal region, where they overlap. In the neck they are distinct and wide apart, and permit the ligamenta sub-flava to be seen from without. In the region of the back they overlap. In the loin, while not overlapping they nearly touch one another, and protect the vertebral canal and contents.

HOMOLOGIES.—Study of the development of the vertebræ has proved that the *transverse processes* of different vertebræ are not of the same homological value.

The anterior tubercle of the transverse process of a cervical vertebra represents, it is thought, a rudiment of a rib, since it answers in position to the rib of a dorsal vertebra, and arises from a distinct centre of ossification. In like manner the transverse process of a lumbar vertebra may be held to be homologous to a rib. The transverse process of a dorsal vertebra is homologous to the posterior tubercle of a cervical vertebra, as well as to the accessory process of a lumbar. Reference to this arrangement furnishes the true explanation of the anomaly of the anterior tubercle of one of the lower cervical vertebræ being found as a true rib-like quantity.

Transition vertebræ.—While the characters of the cervical, dorsal, and lumbar are quite distinctive, the upper dorsal resemble the cervical, and the lower the lumbar. Thus the first and second dorsal vertebræ have bodies recalling those of the cervical; in the tenth to the twelfth dorsal vertebræ, the rudiments of the accessory and mammary processes are present; and the floating rib suggests a lumbar transverse process which is merely unfixed.

DEVELOPMENT.

Each vertebra arises from three main centres of ossification,—one for the body of the bone, and one for each of the two lateral portions, including the laminæ. The centres for the latter appear about the seventh week, and the centre for the body about the eighth week. These parts are separate at birth.

In addition to the above an epiphyseal centre arises within the spinous process and the transverse processes of the vertebræ about the sixteenth year. In the lumbar vertebræ both of the mammillary processes receive a similar centre. The body is furnished with two accessory centres—one on either side—at about the twenty-first year.

The development of the atlas and axis differs from the foregoing.—The *atlas* is without a distinct centre for the body. The two centres of ossification within the laminæ extend across the cartilaginous anterior arches, one or two inconstant centres appearing therein at about the first year.—The *axis* arises from a centre for each lateral mass; one for the body, which appears at the sixth month; and two for the odontoid process, which appear at about the same time. These are united to the body near the third year. An additional accessory centre is seen occupying the odontoid process.

The development of the anterior tubercle of the cervical transverse processes may differ from that of the other vertebræ by reason of the morphological relation existing between this tubercle and one of the series of ribs. The tendency of the tubercle to have a distinct development from the remainder of the transverse process increases as the dorsal vertebræ are approached. The seventh cervical usually possesses a distinct centre in this process. Failure of union between this centre and the rest of the bone gives origin to the so-called cervical rib (see p. 000).

The transverse processes of the lumbar vertebræ may remain distinct from the body of the bone in the manner just indicated.

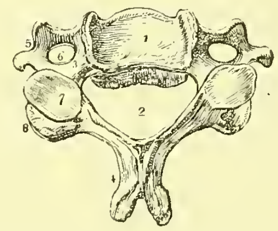
Embryology demonstrates that the vertebral column arises from two distinct portions of the dorsal layer of the embryo. The bodies of the vertebræ arise from beneath the medullary groove in and about the elements of the chorda dorsalis, called the protovertebræ. The elements of the future laminæ lie within the medullary folds at the side of the groove. It is plain that the method of growth of the body is different from that of the laminæ, and that the errors of development witnessed in the latter will be the result of the imperfect approximation between the right and the left sets. The laminæ most frequently failing to unite with one another are at that portion of the column which attains perfection last, namely, the lower portion of the lumbar series. This defect of union is known under the name of spina bifida.

THE CERVICAL VERTEBRÆ.

The cervical vertebræ are the vertebræ of the neck. The *body* of each cervical vertebra (fig. 1, Plate XIII.), excepting that of the atlas and axis, is broader from side to side than from before backwards, and is slightly inclined downward and forward. The upper surface is concave from side to side, and possesses an elevated lateral border. The lower surface is slightly concave from before backward, and yields a pronounced anterior border (fig. 1, Plate XV.). Its lateral edges appear to a trifling extent upon the sides of the body as shallow depressions.

Each *lamina* (Fig. 67) springs from the body at about its middle. The *pedicle* is rounded, and is directed outward until it reaches the mass between the articular processes. Beyond the articular processes the lamina becomes thin and compressed, inclines backward, joining the lamina of the opposite side to form the bifid *spine*, and to give shape to the somewhat triangular vertebral canal. Lying above the

Fig. 67.



1. The body. 2. The vertebral canal, formed at the sides by the laminæ. 3. The pedicle. 4. The laminæ, converging to form the bifid spine. 5. The transverse process. 6. The vertebral foramen. 7. The superior articular process. 8. The inferior articular process. The superior notch is indicated as the space between the body and the superior articular process.

pedicle, and between the lateral border of the body and the superior articular process, is the *superior notch.* Lying below the pedicle, and between the outer side of the body and the inferior articular process, is the *inferior notch.*

The *articular processes* are inclined parallel to one another downward and backward. The *superior articular process* looks upward and backward; the *inferior* looks downward and forward. The portion of bone intervening between the articular processes is massive and columniform.

The *transverse process* arises by two roots—a posterior or larger arising from the pedicle, and an anterior or smaller arising from the body. The process looks directly downward, and is pierced at its base by the *vertebral foramen* for the transmission of the vertebral artery. The process is grooved above for the anterior branches of the cervical plexus (fig. 1, Plate XV.), and presents an anterior and posterior tubercle; the Scalenus Anticus muscle is attached to the former, and the Levator Anguli Scapulæ muscle to the latter. The anterior tubercle, from its serving as a guide for tying the carotid artery, is called by Lisfranc *the carotid tubercle.*

The first (atlas), the second (axis), and the seventh cervical vertebræ (vertebra prominens), having many peculiar features, demand separate descriptions.

THE ATLAS.

The atlas or first cervical vertebra (fig. 2, Plate XIII.) is without body or spinous process. It is further characterized by the greater size of the lateral masses, by the conspicuous transverse processes, by the intervertebral grooves being placed behind the superior articular surface, as well as by many negative features. In place of the body, a short arch is seen which is known as the *anterior surface* or *arch.* This extends between the lateral masses in front, while joining them behind is the larger *posterior surface* or *arch.*

The *anterior arch* arises from the entire anterior borders of the lateral masses. It is compressed from behind forward, and is furnished in front by a prominence known as the *anterior tubercle* for the attachment of the Longus Colli muscle. Behind it is seen a large facet for articulation with the odontoid process of the axis.

The *posterior arch* arises from the middle of the posterior border of the lateral mass, where it is compressed from above downward, and grooved (*sinus atlantis* or *intervertebral groove*) for the vertebral artery. The hinder portion is more robust, and yields a minute *tubercle* for origin of the Rectus Capitis Posticus Minor muscle.

The *transverse process* is directed slightly downward and outward, and presents a broad, scarcely bifid extremity. Its anterior root arises from the upper border of the lateral mass; that portion behind the foramen arises from the middle of the lateral mass, and merges thence with the origin of the posterior arch. The under surface of the process is roughened. The transverse process, as in the other vertebræ, excepting the seventh, transmits the vertebral artery. Each lateral mass presents above and below an articular surface, and the two elements defining the vertebral foramen are more completely fused beyond the foramen than in the other vertebræ.

The *superior articular process* is of an oblong shape, and is concave for articulation with the occipital condyle. Its anterior and lateral edges are thin, and nearly on a level with the anterior arch. The posterior border is thickened, and forms a projection above the groove for the vertebral artery and first cervical or suboccipital nerve.

The *lower articular* process is more rounded than the upper. It is scarcely at all concave, and is directed obliquely upward and inward, and often slightly projects at the sides and in front.

The inner border of the lateral mass is roughened, and lies within the vertebral canal. It presents a tubercle, lying directly above the inner border of the inferior articular surface, for attachment of the transverse ligament.

The vertebral canal is relatively larger than in other vertebræ, and is remarkable for its contraction between the lateral masses for the accommodation of the odontoid process and the crucial and the check ligaments (fig. 2, Plate XXXVI.). The posterior half of the canal defined between the laminæ is wider than deep, and receives the spinal cord and vertebral arteries and veins (fig. 3, Plate XXXVI.).

REMARKS.—The *sinus atlantis* may be converted by an osseous bar into a foramen.—A spicule of bone may spring from the posterior arch at the upper surface of the point of junction of the lamina and the pedicle, and pass over the position of the vertebral artery and the suboccipital nerve to the back part of the superior articular surface. A second spicule may pass from the upper surface of the transverse process to the outer edge of the superior articular surface,

crossing the place of exit of the anterior division of the first spinal nerve.[1]

The atlas tends in its varieties to hypertrophy of its lateral and atrophy or defective development of its median parts. The former variety may have the anterior tubercle of exaggerated size, when the prominence felt in the neck behind the angle of the lower jaw would be larger than usual; a process of bone may arise from the upper surface, and may even join the rarely present para-mastoid of the occipital bone. Of the latter variety, the anterior arch may be imperfectly ossified and a joint intervene, and the posterior arch be entirely absent, or a median hiatus of considerable size may exist which is occupied by fibrous tissue.

In a very instructive case reported by Küssmaul and Tenner,[2] an exact relation was detected between defective development of the atlas and the recurrence of epileptic convulsions. The patient was a boy twelve years of age, and the attacks supervened only upon rotation of the head. The coincidence of this motion with the attacks led to a careful examination of the parts after death. The defect of development described in the preceding paragraph was found to exist. The right segment of the imperfect arch passed across the median line nearly to the opposite side of the bone, and overlapped the left segment by one-third of an inch. The head being strongly rotated upon the spine, the ends of the imperfect posterior arch were seen to move forward, and in so doing the capacity of the vertebral canal was diminished and its contents compressed. It was inferred by the reporters that such action of the parts had followed each act of rotation during life, and, as a result of the spinal compression in this way induced, the convulsions had ensued. This conclusion appears to be a reasonable one, since it is in full harmony with the causation of at least one form of epilepsy as defined by writers on nervous disease, namely, that caused by pressure against the brain and spinal cord from exostoses, etc.

It is seen from this case that a deformation, which is at first sight of purely theoretical significance may be of great importance as an exciting cause to diseased action.

[1] W. Allen, Journ. Anat. and Phys., xiv., 1879, 18.

[2] Moleschott's Untersuchungen zur Naturlehre der Menschen und der Thiere, 1857, iii. 122.

THE AXIS.

The axis or second cervical vertebra (figs. 3 and 4, Plate XIII.) presents a body which is compressed from before backwards and furnished above with a conspicuous tooth-like process,—the odontoid process. The *laminæ* of the axis are massive, but its transverse processes are small and possess but a single tubercle. As is the case with the atlas there is no superior notch, *i. e.*, the superior facet is placed in front of the intervertebral groove.

The *body* of the axis is marked in front by a vertical eminence, upon either side of which is a depression for attachment of the Longus Colli muscle.

The *anterior border* of the under surface is produced below the level of the posterior.

The *lower surface* is moderately concave for reception of the third cervical vertebra.

The *upper surface* is furnished with the conspicuous *odontoid process.* This is a vertical cylindrical eminence, whose anterior surface is slightly inclined backward, but whose posterior surface is nearly vertical. Its lip is sometimes prolonged. The lateral surfaces of the process near the lip are depressed for attachment of the powerful check ligaments. The process is constricted at the base behind, and at the sides by a well-defined neck for the accommodation of the transverse ligament. The anterior surface presents an oval facet for articulation with the atlas (fig. 3, Plate XXXVI.).

The *laminæ* of the axis arise from nearly the entire side of the body; directly behind the superior articular process the upper border is faintly depressed to form the *inter-vertebral groove* for the passage of the second cervical nerve. The *spinous process* is mas-

EXPLANATION OF PLATE XIII.

Fig. 1. A cervical vertebra, seen from in front.
Fig. 2. The atlas, seen from above.
Fig. 3. The axis, seen from the side.
Fig. 4. The axis, seen from in front.
Fig. 5. A dorsal vertebra, seen from in front.
Fig. 6. A dorsal vertebra, seen from the side.
Fig. 7. A lumbar vertebra, seen from in front.
Fig. 8. A lumbar vertebra, seen from the side.

PLATE XIII

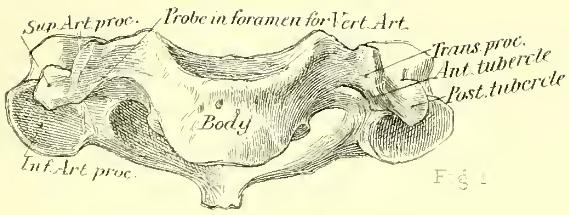
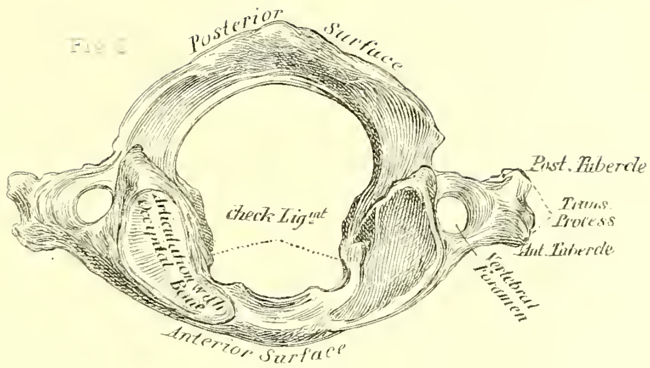


Fig 1

Fig 2



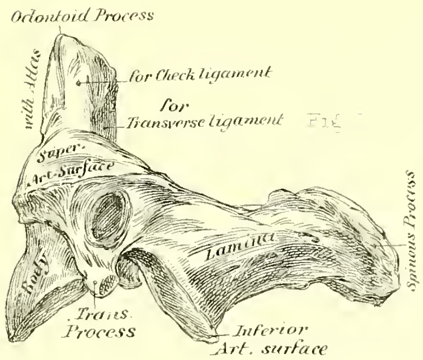


Fig 3

Fig 4

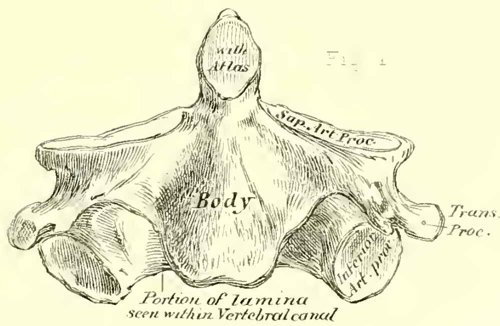


Fig 5

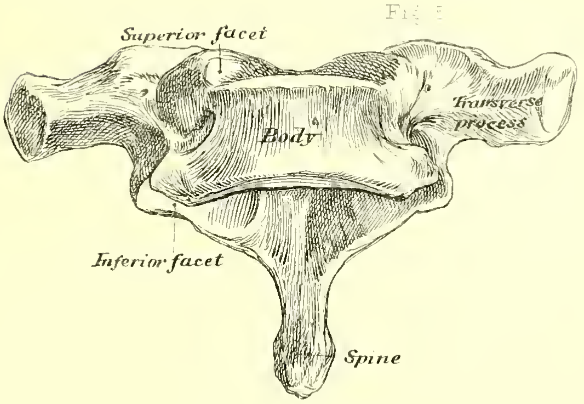


Fig 6

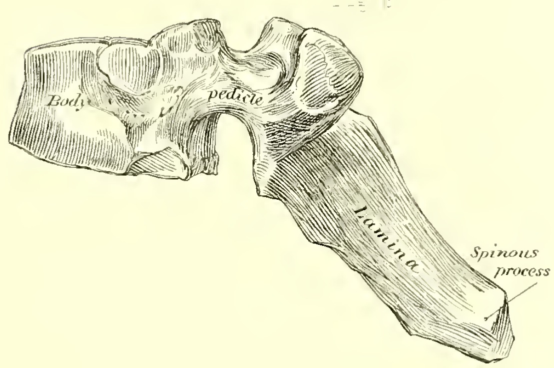


Fig 7

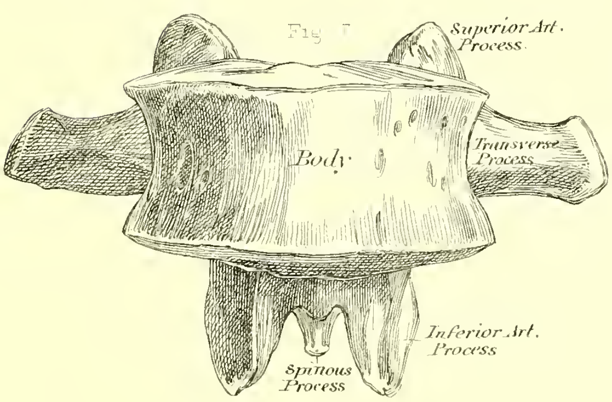
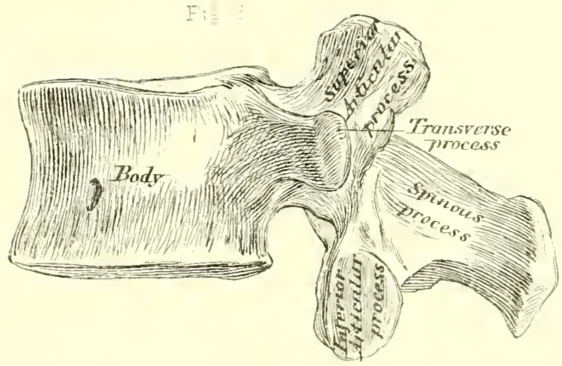


Fig 8



sive and bifid, and beneath is grooved its entire length.

The *superior articular process* is placed near the base of the odontoid process. It is concave from side to side. Its outer half lies directly above the transverse process, projects in front, and faces upward.

The *inferior articular process* is not placed beneath the superior but upon the lamina. It is inclined upward, forward, and faces forward.

The *transverse process* is placed beneath the superior articular process. It extends abruptly downward and backward. The process is but faintly grooved above. Its foramen is directed outward.

Structure.—The cancelli are figured by Luschka as more compact in the odontoid process than in the body. Humphry describes and figures this compactness as decided. The denser part forms a division between the more cancellous apex and the rest of the process. K. Bardeleben[1] figures the process as almost entirely compact. Dr. C. T. Hunter has detected in the process a special arrangement of trabecular fibres beneath this compact tissue much weaker than those ordinarily met with in the interior of the other vertebræ. In the judgment of this observer the frequency of fracture at the neck is hereby explained. It is evident from the foregoing statements that the odontoid process is more compact than the rest of the axis, but that in the degree of its compactness and arrangement of the cancelli at its neck there is some variation.—Dr. Reid[2] has recorded an instance of conical exostosis of the odontoid process which induced compression of the spinal cord and death.

P. Devan[3] reports a case in which the odontoid process which had been separated from the body of the axis by fracture, had united to the edge of the foramen magnum, thus emphasizing the relation occasionally seen between these parts in the uninjured subject.

Remarks.—As an exceedingly rare formation the tip of the odontoid process may be prolonged upward and articulate with the anterior border of the foramen magnum. According to Luschka, the tip of the spinous process receives a distinct centre of ossification.

The neck of the odontoid process is the weakest part of the bone, and that portion which is most frequently the seat of fracture. Humphry[1] describes this as a very rare condition, he having seen but two examples.

[1] Beiträge zur Anatomie der Wirbelsäule, Jena, 1874, Faf. 1, fig. 23.

[2] Lond. and Edin. Journ. Med. Sci., 1843.

[3] Dublin Medical Press, Feb. 18, 1863.

THE SEVENTH CERVICAL VERTEBRA.

The seventh cervical vertebra presents the following peculiarities: The articular processes are almost vertical, are not supported by small columns, and do not lie directly one above the other. The foramen at its base does not transmit the vertebral artery. The body is without median projection. There is sometimes one-fourth of a facet for articulation with the head of the first rib. The lateral extension of the lower surface of the vertebra may be almost entirely absent. The spinous process is very large, resembles that of a dorsal vertebra, and is without a groove. While not bifid it is much larger than any other of the cervical series, and forms in the subject a distinct prominence beneath the skin. From this feature the bone has received the name of the "vertebra prominens." The process gives attachment to the nuchal ligament. According to Luschka the spinous process is often fractured. It was once so found by this observer in the body of an epileptic patient under circumstances suggestive of the fact that the lesion had occurred as the result of a fall during a convulsion.

Remarks upon the Cervical Vertebræ as a Whole.—The portion of the spine composed of the cervical vertebræ is at once the most flexible and most varied in form, while the most constant in the number of its elements.

The position of the cervical vertebræ can be made out in a satisfactory degree in the living subject. The fact that the anterior surfaces of the bodies lie directly behind the pharynx and the beginning of the œsophagus enables the finger to freely define the position of the second to fifth vertebræ through the posterior wall of the pharynx. The rounded nodule on a level with the base of the uvula is the atlas. It varies in degree of prominence. It is not to be confounded with a transverse fold of induration seen in the same neighborhood in certain abnormal conditions of the pharynx. The smooth surface directly in view when the mouth is open answers to the axis, which extends from the position of the nodule to the tip of the epiglottis. Behind the free portion of the epiglottis lies the body of the third vertebra; behind the fixed por-

[1] Loc. cit. 131.

tion of the cartilage, the fourth; behind the cricoid cartilage, the fifth and sixth. The atlas-nodule is always distinct in the adult; the remaining points are variable. In some subjects a uniform median keel-like ridge can be readily felt the entire length of the pharynx.

The formation of pus behind the pharynx is sometimes caused by diseased vertebræ; and in necrosis of the atlas and axis portions of these bones have been ejected into the pharynx (see Pharynx). In like manner, after fracture of the odontoid process, the detached fragment has been known to escape by perforation of the pharyngeal wall.

On the sides of the neck the transverse processes can be distinctly felt beneath the skin in emaciated subjects. The distance between the transverse process of the atlas and the angle of the lower jaw is not greater than half an inch. In dissection the process is not exposed until the anterior tendinous margin of the Sterno-Cleido-Mastoid muscle is raised from over it, the tough fibrous tissue is removed, and a deep-seated lymphatic gland which is lodged below the process is pressed aside. The process in reality belongs, clinically speaking, to the region about and behind the angle of the jaw. Its condition should be carefully eliminated in making a diagnosis of tumors of this region. H. J. Bigelow[1] believes that cystic tumors of the neck almost always arise from the parts about this transverse process and the styloid process of the temporal bone. The styloid process extends downward and forward one-third of an inch between the angle of the jaw and the transverse process. Further down the neck the transverse processes can be felt by deep palpation. They serve as valuable guides in making incisions for reaching the track of the great vessels in ligation, and for the position of the œsophagus in œsophagotomy.

Posteriorly the third, sixth, and seventh spines can alone be felt. The remaining spines are thickly covered by the soft parts. The apex of the lung answers to the spine of the seventh vertebra. It is about this spine that a peculiar neuralgic pain often radiates in anæmic persons.

Specimens are occasionally met with in the collections where the atlas and the skull become anchylosed. After fracture in this region the reparative process is active, so that union of the fragments takes place should the patient survive the immediate effects of narrowing of the vertebral canal.

The deformations arising from malposition of the vertebræ are to be carefully separated from those due to muscular contraction or wry neck.

[1] Bost. Med. and Surg. Journ., vol. lxxxvii. 279.

F. R. Lente[1] has reported the rare anomaly of a vertebral column possessing but six cervical vertebræ.[2]

The Cervical Rib.—The anterior portion of the transverse process of the seventh vertebra bearing the anterior tubercle is sometimes imperfectly anchylosed to the body. When thus free it has received the name of the cervical rib, since it is homologous with a true rib. Its anterior extremity may be free or be joined to the first true rib. The presence of a cervical rib may interfere with the normal relations of the subclavian artery, diminish the circulation of the upper extremity, or induce pressure upon the brachial plexus. An exostosis growing from such a rib was detected by Holmes Coate[3] on the left side in a female aged 26. The condition was thought to be congenital, at least it had existed since early childhood. The growth was successfully removed by operation. The circulation of the limb remained unimpaired. The cervical rib has been the subject of special memoirs by Halbertsma,[4] Luschka,[5] Struthers,[6] Gruber,[7] and Turner.[8]

THE DORSAL VERTEBRÆ.

The dorsal vertebræ are the vertebræ of the chest or thorax. Each bone is distinguished by the presence on the side of the body of a depression for the head of its associated rib. The two upper dorsals resemble the type of the cervicals, the lower dorsals resemble the type of the lumbar vertebræ. Rudiments of the true transverse and mammillary processes are seen on the bodies of the eleventh and twelfth.

The *body*, figs. 5 and 6, Plate XIII., is narrower in front than behind. From the third to the eighth the bodies are convex in front and concave behind to

[1] N. Y. Journ. of Medicine, 1850, 285.

[2] For an account of the homologies of the atlas, axis, and those of the occipital bone, in connection with these bones, see Cleland, Nat. Hist. Rev. Ap. 1861, also W. Allen, Journ. Anat. and Phys. xiv. 1879, 18.

[3] Med. Times and Gazette, Ap. 3d, 1861, 108.

[4] Roy. Acad. Sci. Amsterdam, 1856, 238.

[5] Denkschriften der m. n. Klasse der Kais. Acad. der Wissenschaften, Berlin, xvi.

[6] Ed. Monthly Med. Sci. xvii. 1853, 292.

[7] Mem. Acad. Imper. St. Petersburg, xiii. 1869.

[8] Journ. of Anat. and Physiol. iv. 1870, 130.

form the anterior border of vertebral foramen. In the last four the posterior surfaces are flat.

The transverse sections of the bodies of the upper and lower vertebræ exhibit oval figures, while those of the middle are triangular, with sub-rounded angles. The anterior surface of each body is sometimes called the *visceral* surface from its relation to the thoracic viscera, when the posterior becomes the *vertebral*, or *spinal* surface. The upper and lower surfaces are not parallel, but may be slightly inclined toward one another.

The *depression for the rib* is variable in shape, but is for the most part of a modified semilunar figure. The upper nine vertebræ have for this purpose two demi-facets, one at the upper at the junction of the body and the lamina, at the other at the lower border of the body near the vertebral border. In the eleventh and twelfth ribs the single facet is placed more upon the lamina than in the others.

The *pedicle* arises from the body at its upper half and at its side. While the lower border is rounded, the upper is sharp. At the same time the upper notch is shallow, and looks upward and inward, while the inferior is deep. In the first dorsal vertebra the pedicles are cylindrical. The upper notch is deep and semicircular, and looks upward.

The *laminæ* are broad and thin, and soon unite to form the broadly-based spinous process. At the pedicles the laminæ are horizontal; but beyond the superior articular process of each side the laminæ are deflected abruptly downwards on the same plane with that of the spinous process.

The superior articular processes are both nearly on the same plane with the laminæ, and look backward. *The inferior articular processes* look forward, excepting those of the twelfth vertebra, which look laterally. The so-called *transverse process* is a conspicuous robust projection, nearly as broad as the body. It is directed laterally and a little backward. Its anterior surface is rounded by a facet for articulation with the corresponding rib. The *true* transverse process, viz., that which is homologous with the posterior tubercle of the cervical vertebræ, is not seen in the dorsal vertebræ until the tenth and eleventh are reached as already mentioned. In the lumbar vertebræ they again appear.

THE DORSAL VERTEBRÆ AS A WHOLE.—When the twelve dorsal vertebræ are articulated they are seen to form a column whose anterior surface is concave. The spinous processes, notwithstanding their relatively great length, project not directly backward, but obliquely downward and backward. The laminæ thus overlap—less at the beginning and the end of the column than toward its middle. A degree of strength is thus secured to the dorsal region over and above that secured by the articular surfaces against one another, while the vertebral canal receives an additional protection. The ribs still further aid in protecting and fixing the dorsal region, which is as a result the best preserved from injury, while the most rigid, of any portion of the spine. Exostoses of the vertebral canal are rare. Humphry[1] mentions a case in which a bony outgrowth had projected from the hinder surface of one of the dorsal vertebræ and had pressed upon the cord, inducing paralysis of the lower extremities.

THE LUMBAR VERTEBRÆ.

The lumbar vertebræ are the vertebræ of the loins. Each bone (figs. 7 and 8, Plate XIII.) possesses a massive body, which is wider from side to side than from before backwards. Its nutritive foramina are more conspicuous than in other vertebræ. These are especially well developed upon the posterior surface, where they form two openings for the basi-vertebral veins upon either side of a faint median ridge. The latter is often absent, when the openings are confluent.

The *laminæ* are correspondingly massive with the body. The *pedicles* arise from the upper half or two-thirds of the body. They are short, but heavy, and support the transverse and superior articular processes. These latter structures may be studied in the following order: The *transverse process* (homologous with a rudimentary rib) arises from the outer side of the pedicle at the base of the superior articular process. It is broad and compressed laterally, and is directed outward and backward. The *superior articular process* presents a concave facet directed inwards and backwards. The outer surface of the process yields at its posterior border a rounded eminence projecting backward beyond the facet, the *mammillary process* for the origin of the slip of the Multifides Spinæ muscle. Behind the base of the transverse process is seen the *accessory process*, which is a faint ridge-like projection representing a rudiment of the transverse process of the dorsal vertebræ.

The *spinous process* is very broad, directed horizontally backward from the laminæ. It is thin above, broad below, whence its contours are continuous with the *inferior articular processes*. The latter are nearer

[1] Human Skeleton, 157.

one another than are the upper. They are deflected at a right angle from the lamina of its own side. The facets are vertical, slightly convex, and look outward and backward.

The *vertebral canal* is triangular, with sub-rounded angles, or is lozenge-shaped.

The curve of the lumbar column is very slight, and is so directed as to be convex forward. To this effect both the bones and the shapes of the intervertebral disks contribute.

Friction facets are often seen between opposed borders of the spinous processes, and occasionally a distinct interspinous joint forms. The fifth vertebra is deeper at the anterior than at the posterior margin. The transverse processes lie in a series with the lower so-called transverse processes and with the ribs of the dorsal vertebræ.

REMARKS ON THE VERTEBRAL COLUMN AS A WHOLE.

The applications to practice that can be made of a knowledge of the anatomy of the vertebral column are numerous and important.

It is necessary to remember that the spine is secured in position by the joints between the vertebræ. The variations of the shape of the column are due to the dispositions of the joints as well as of the bones.

Destruction of the bodies of the vertebræ so far interferes with the lines of support already mentioned as to throw the weight of the superimposed mass upon the laminæ. These are not adapted to sustain such weight, save only in the cervical vertebræ; and when, as is frequently the case, the dorsal vertebræ are involved, the drag of the ribs, sternum, and their muscular and visceral attachments create an exaggerated antero-posterior curvature of the dorsal vertebræ, ending in deformity not only at the portion of the spine thus yielding, but in others, so that a group of secondary changes in the entire vertebral column arise, distorting or obliterating the normal curves.

Roslan, according to Portal,[1] has found a greater tendency to displacement on the parts of the bones of the vertebral column to exist between the last dorsal and the first lumbar vertebra than elsewhere. Jeffries Wyman,[1] in reaffirming that the lumbar region is the weakest portion of the lumbar arch notwithstanding its increased bulk when compared to the other regions of the spine, uses the following language:—

"In dorsal vertebræ the arches are characterized by the breadth of the laminæ and by having the transverse processes implanted just between the articular ones, where, in consequence, the arch becomes greatly strengthened, in fact, has its greatest strength. In the lumbar region the transverse processes are thrown further forward, so as to rest more upon the pedicle, while the upper and lower articulating ones become more widely separated from each other, the lower ones being carried downwards, and the bone connecting them so contracted as to form a somewhat slender neck; thus the part in question becomes the weakest instead of the strongest portion of the arch."

Malgaigne, while recognizing the weak point above defined, gives two others, one at the junction of the cervicals and the dorsals, and the other at the junction of the lumbar vertebræ and the sacrum;—in a word, including *all* the vertebræ of transition.

Humphry has cited a number of related causes in explanation of the same group of facts. Since, for example, "the transverse processes being very short, while the long transverse processes in the lower part of the loin, added to the projecting crest of the ilium below, and the false and true ribs above, afford to the several muscles a powerful leverage acting upon this junction on either side and in front. It is near the middle of the column, so that a greater length of leverage can be brought to bear against it than at any other part."

The next weakest point in the vertebral column is the dorsal region. Fracture is relatively frequent here, and, as already stated, antero-posterior curvature of the spine is common.

Dr. D. J. Cunningham[2] has observed a vertebral

[1] Anat. Med. I. 295, note.

[1] Bost. Med. and Surg. Journ. 1869.

[2] Journ. Anat. and Phys. 1878, 89.

EXPLANATION OF PLATE XIV.

Fig. 1. The sacrum, seen from in front.

The reader should read the word "promontory" as referring to the anterior surface of the first sacral vertebra at its upper part.

Fig. 2. The sacrum, seen from the side.

Instead of "for sacral vertebra," read "1st sacral vertebra."

Fig. 3. The sacrum, seen from behind.

Fig. 4. The coccyx, seen from behind.

Fig 1

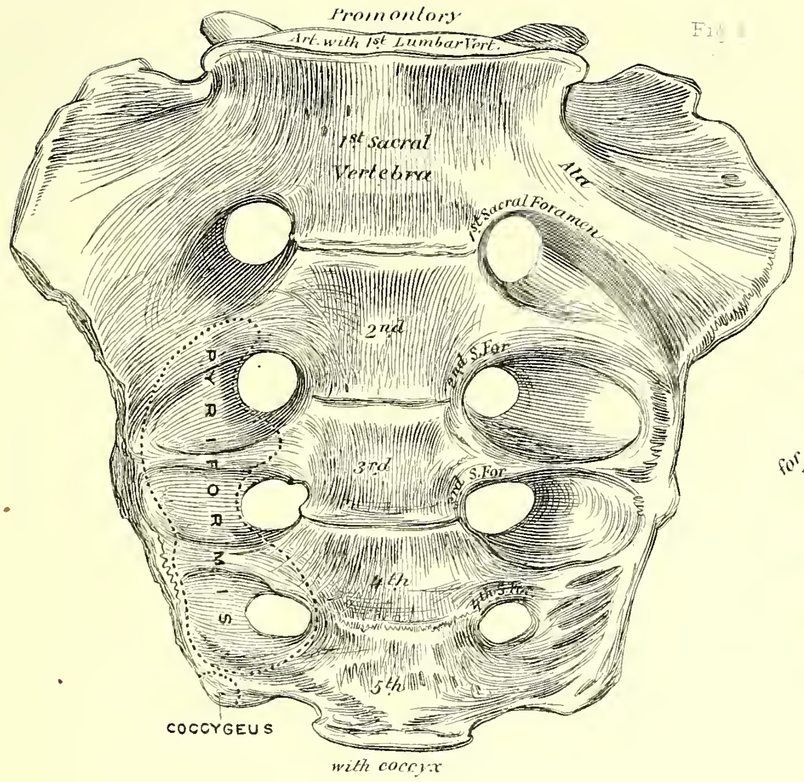


Fig 2

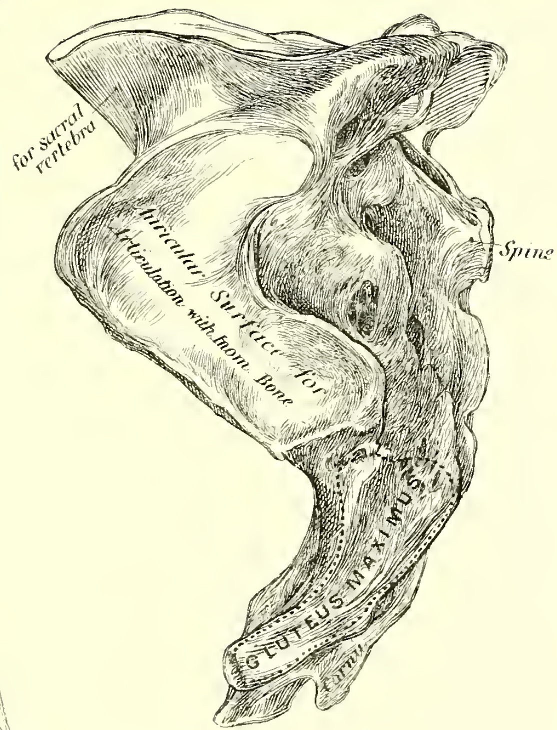


Fig 3

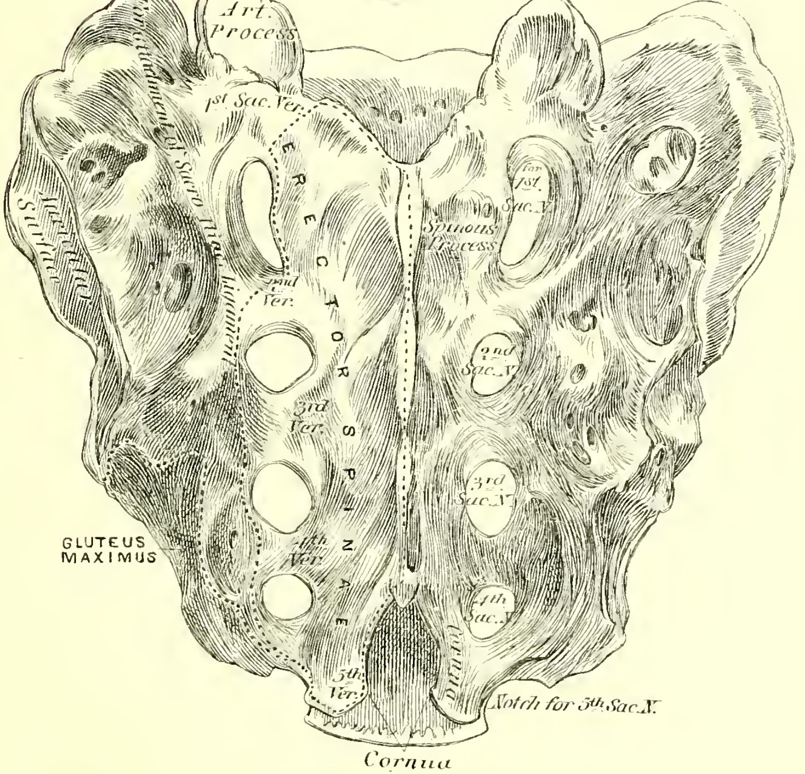
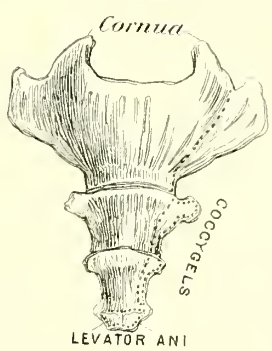


Fig 4



column in which the epiphysial processes of the mammillary processes of the twelfth dorsal remained distinct; as also did the fused mammillary and accessory processes of the first lumbar vertebra. The spinous process of the first dorsal and the transverse process of the seventh dorsal in like manner presented detached epiphysial bones.

TABULAR PLAN OF PARTS OPPOSITE THE SPINES OF THE VERTEBRA. (Holden.)

CERVICAL.	7th.	Apex of lung; higher in the female than in the male. (30)
DORSAL SPINES.	1st.	
	2d.	
	3d.	Aorta reaches spine. Apex of lower lobe of lung. Angle of bifurcation of trachea. (49)
	4th.	Aortic arch ends. Upper level of heart.
	5th.	
	6th.	
	7th.	
	8th.	Lower level of heart. Central tendon of diaphragm.
	9th.	Œsophagus and vena cava through diaphragm. Upper edge of spleen.
	10th.	Lower edge of lung. Liver comes to surface posteriorly. Cardiac orifice of stomach.
	11th.	Lower border of spleen. Renal capsule.
	12th.	Lowest part of pleura. Aorta through diaphragm. Pylorus.
LUMBAR.	1st.	Renal arteries. Pelvis of kidney. (83)
	2d.	Termination of spinal cord. Pancreas. Duodenum just below. Receptaculum chyli.
	3d.	Umbilicus. Lower border of kidney.
	4th.	Division of aorta. (65) Highest part of ilium.
	5th.	

According to the same authority, the spine of the second dorsal corresponds with the head of the third rib; the spine of the third dorsal with the head of the fourth rib; and so on until we come to the eleventh and twelfth dorsal vertebræ, which so tally with their corresponding ribs.[1]

[1] For other relations, see Tabular Relations between the anterior and posterior surfaces of the thorax.

THE SACRUM.

The sacrum (figs. 1, 2, 3, Plate XIV.) is formed by the fusion of the five vertebræ which intervene between the lumbar vertebræ and the coccyx. The lines of union of the bodies of the vertebræ can be distinguished in front by four transverse ridges representing the position of the ossified intervertebral disks; and behind by a median row of tubercles which represent the dorsal vertebral spines. The intervertebral foramina are seen under the name of the *sacral foramina;* and the vertebral canal under the name of the *sacral canal.*

The sacrum is the broadest part of the vertebral column, and forms the posterior wall of the pelvis. The bone has been compared to a wedge. Its antero-posterior curvature impairs the value of this figure somewhat. The first sacral vertebra closely resembles the last lumbar vertebra both in appearance and in size; the remaining segments gradually lose resemblance to vertebræ, the last, indeed, retaining little beyond a body and imperfect laminæ.

The sacrum presents for examination a base, an apex, and anterior, posterior, and lateral surfaces.

The *base* has a broad surface, which corresponds to the body of the last lumbar vertebræ, and a pair of well-defined sacral articular processes which join the inferior lumbar processes of the same name. The *apex* is small, and articulates with the coccyx by a narrow oval surface.

The *anterior surface* (fig. 1, Plate XIV.) is concave and nearly smooth. It is ridged transversely by the four lines of union between the several vertebræ. The spaces between the terminations of these ridges and the lateral surfaces are called the *lateral masses*, and are marked by four broad and shallow grooves for the anterior sacral nerves. The anterior upper portions of the sacrum are often spoken of as the wings or *alæ.* The Pyriformis muscle arises from the lower two-thirds of the lateral mass, and the Coccygeus arises in part from its inferior portion.

The *posterior surface* (fig. 3, Plate XIV.) is narrower and more irregular than the anterior. The laminæ, dorsal spines, articular and transverse processes unite with one another without suture, thus covering in the sacral canal except at a small space behind the first and last sacral vertebræ, where, as a result, the *superior* and *inferior sacral notches*, respectively, are defined. The laminæ blend to form a continuous surface on either side of the median row of tubercles which are the rudiments of the dorsal spines. This surface would be smooth throughout, were it not for the nodosi-

ties which stand for the pairs of coalesced articular and mammillary processes of the sacral vertebræ. They are ranged in a linear series between the more conspicuous dorsal spines and the posterior sacral foramina. The terminations of the line of articular processes form noticeable projections; the inferior of these are called *the sacral cornua*. To the outer side of these foramina are placed the less perfectly marked remains of the lumbar transverse processes. By reason of these numerous modifications of the vertebræ, the vertebral grooves are shallow and imperfectly defined. The posterior sacral foramina are much smaller than the anterior, and are not accompanied with grooves. The posterior surface gives origin to the Gluteus Maximus and Coccygeus muscles, and to the vertebral aponeurosis.

The *lateral surfaces* (fig. 2, Plate XIV.) are divided into two portions, which differ widely in their degrees of departure from the vertebral plan. Each surface answers to the sides of the first three vertebræ, is broad and thick, and in the fresh condition of the bone is occupied by an ear-shaped surface of cartilage (*auricular surface*) for articulation with the corresponding innominate bone. Below the auricular surface the lateral surface is compressed, notched, and without articulation. Above, it affords attachment to the sacro-sciatic ligament.

Viewed as a portion of the spinal column the sacrum presents an abrupt anterior convexity opposite the first sacral vertebra, called the *promontory* of the sacrum. This eminence may so vary as to be opposite to the second sacral vertebra. Below this is a gentle concavity, which assists in forming the superior outlet of the pelvis, and in supporting the pelvic viscera.

In uniting with the lumbar vertebra an opening of variable size is formed between the laminæ of the vertebræ and the first dorsal tubercle of the sacrum. Hence the vertebral canal is not well protected at this point. When from any defect in the development of the posterior surface this opening is preternaturally large, we have the condition known as spina bifida. Spina bifida may in this way be confined to the upper portion of the sacrum, or it may involve the entire bone and even the lumbar vertebræ. In addition to the above the union converts the supra-intervertebral notch into a foramen of the same name. Union with the coccyx converts the intervertebral notch at the lower border of the sacrum into a foramen; and union with the innominate bone converts the notch at the lower border of the lateral surface into a foramen which transmits the fifth sacral nerve.

Development.—The sacrum develops after the manner of the vertebræ, of the elements of which indeed it is composed. Thus there is one centre each for the bodies of the vertebræ, and one each for the laminæ posteriorly, as well as for the tubercles which answer to the mammillary tubercles of the lumbar vertebræ. Epiphyses, similar to those seen elsewhere in the vertebral column, arise upon the bodies of the vertebræ. In addition to these vertebral characteristics the sacrum presents a new ossification upon its lateral surfaces. These are two in number on each side, and resemble generally the epiphyses upon the vertebræ. The following is the order in the development of the parts of the sacrum:—

Ossification takes place in the bodies and laminæ at the eighth or ninth week; the laminæ begin to ossify at the sixth month; the union of the laminæ with the body in the lower vertebræ occurs in the second year, and in the upper later, namely, at about the fifth or sixth year. The epiphysial and lateral plates are formed at the sixteenth year, and completed at the twenty-fifth. The bodies of the sacral vertebræ unite slowly. The process is completed from below upward, as with the laminæ, at about the twenty-fifth year. (Quain.)

Articulations.—The sacrum articulates with the last lumbar vertebra above, the coccyx below, and the innominate bones at the sides.

Remarks.—The promontory of the sacrum can be readily felt by rectal examination.

EXPLANATION OF PLATE XV.

Fig. 1. The vertebral column, seen from the side.

Fig. 2. The dorsal vertebræ and portions of ribs in position, showing the method of union between the ribs and the vertebræ. From a dried preparation. The curve of the column is distorted, and the lines of union of the heads of the ribs with the vertebræ are too irregular.

PLATE XV

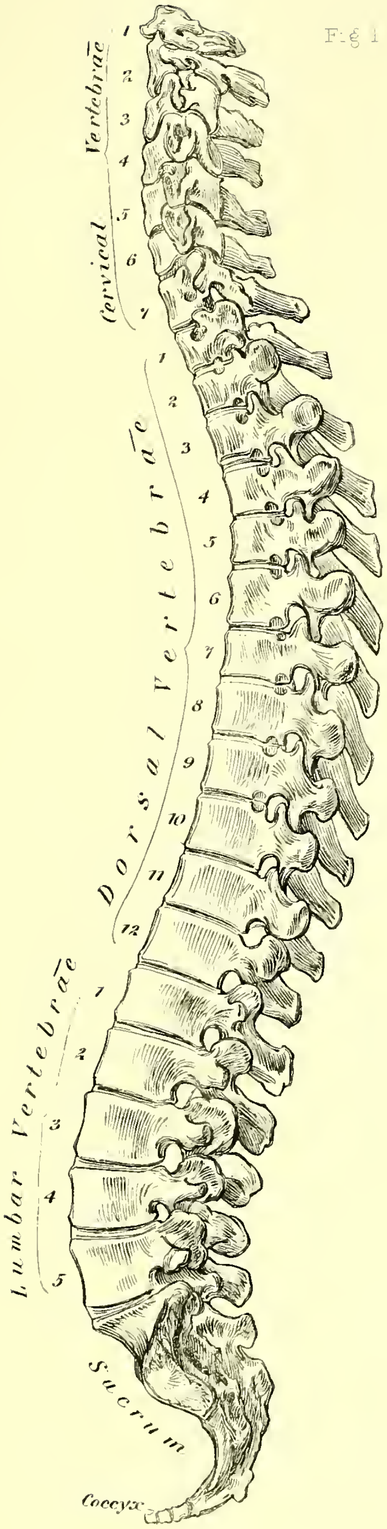


Fig 1

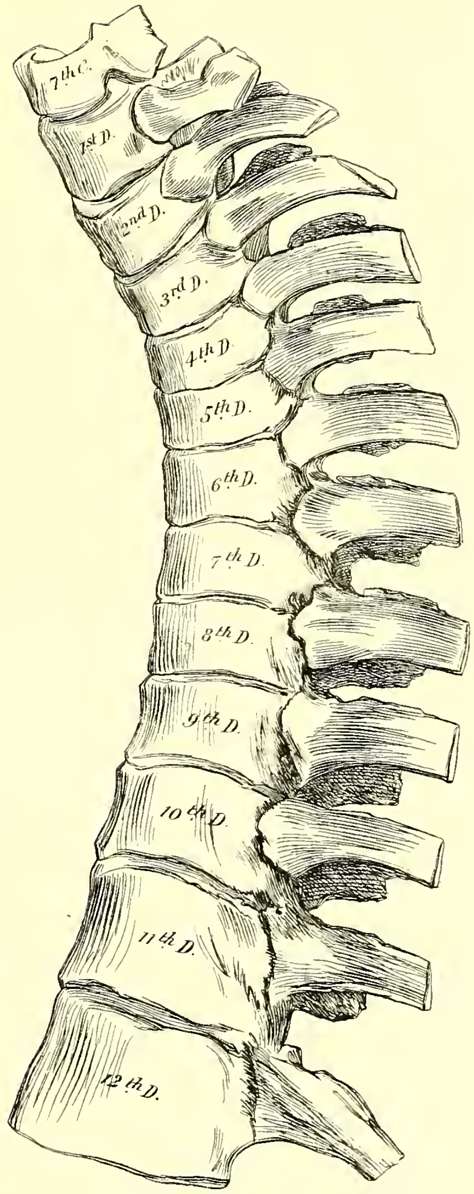


Fig 2

T. Sinclair & Son Lith.

The base of the sacrum is about on the level of the anterior superior spinous processes; the position of the promontory can thus be accurately determined.

THE COCCYX.

The coccyx is composed of the rudiments of four vertebræ. This number may be increased to five, or even be reduced to three. The coccyx has neither arches nor spinal canal. The bones arrange themselves in a series resembling that seen in the sacrum, inasmuch as the first is the largest, and the last is the smallest: the resultant figure is therefore wedge-shaped. The first vertebra is usually distinct, while the remaining are co-ossified, the limiting ridges alone indicating the lines of union. The first vertebra possesses a pair of ascending processes (*the coccygeal cornua*), posteriorly, which are in the line with the articular processes of the sacrum, and which may be considered to be rudiments of the laminæ. Well-defined rudiments of transverse processes exist in this member of the series alone.

The second and third coccygeal vertebræ are much compressed from above downward, and triangular in form; while the remaining portion of the bone is pyriform. The first coccygeal vertebra unites with the second, and also with the sacrum in the adult period. Such union is subject to much variation. An intervertebral disk exists ordinarily between the coccyx and the sacrum.

Development.—The coccyx arises from four centres of development. Ordinarily each bone arises from a distinct centre; the upper may arise from two. The first becomes osseous at birth; the second at from the fifth to the tenth year; the third before puberty; and the fourth after puberty.

Remarks.—The coccyx can be readily felt by rectal or even vaginal examination. It has been often fractured by external violence; and in parturition, where marked sacral curvature exists, it is often either fractured or displaced. The greatest interest centring about the coccyx relates to the painful affection known as coccygodynia. In connection with the structural changes associated with this disease the student should carefully study the ligaments and nerves of the coccyx, and the muscles inserted into it, as well as the position of the coccygeal body. Among the causes of this affection may be mentioned inflammation of the bone and ligaments, contracture of the muscles, and enlargement of the coccygeal body. Verneuil[1] proposes to remove the coccyx as a preliminary procedure to perineal section in cases of imperforate rectum. The assertion is made that the operation is without danger.

For the relation existing between the curvature of the sacrum with the coccyx and the genital cleft, see the account of the female organs.

THE BONES OF THE HEAD.

The skull is composed of two sets of bones: one defines the brain-case and constitutes the *cranium* proper; and the other defines the nasal and orbital cavities, at the same time affording protection to the teeth, and constitutes the *face*.

The bones of the cranium are eight in number,—

The occipital,	The two parietals,
The two temporals,	The frontal,
The sphenoid,	The ethmoid.

The bones of the face are fourteen in number,—

The vomer,
The two superior maxillæ,
The two palatals,
The two inferior turbinated bones,
The two malars,
The two lachrymals,
The two nasals,
The inferior maxilla.

All the bones of the head, with the exception of the inferior maxilla, are immovably united together.

THE OCCIPITAL BONE.

The occipital bone (figs. 1, 2, 3, Plate XVI.; also, fig. 2, Plate XXXVI.) is situated at the base and posterior part of the cranium. It is slightly curved from above downward, and seen in profile is of a crescentic figure. The part of the figure in advance of the conspicuous condyles passes upward and forward, and forms the *basilar portion* of the bone; that to the outer side of the condyles forms the *lateral portion;* and that behind, passing backward and upward, forms the *ascending portion.* Between the condyles, and extending thence backward, lies the *foramen magnum.* This is a large oval foramen, somewhat longer than wide, and wider behind than in front.

The occipital bone articulates with the sphenoid bone and with the parietal and temporal bones. It affords

[1] Gaz. des Hôpitaux, Nos. 87 and 90, 1873.

protection to the cerebellum and the occipital lobes of the cerebrum within, and yields points of origin to important bones without. In advance of the condyles it assists in forming the roof of the pharynx; and behind in defining the occiput and post-atlantal space. The foramen magnum transmits the medulla oblongata, the vertebral arteries, and the spinal accessory nerves. These structures do not entirely occupy the opening, the space between the medulla and the margin being filled by the cerebro-spinal fluid.

The *basilar portion* of the occipital bone is an oblong figure, and abruptly truncate in front, where it joins the body of the sphenoid bone. It is wedge-shaped—the base of the wedge constituting the surface that articulates with the body of the sphenoid, the edge forming in great part the anterior margin of the foramen magnum. The basilar process presents four surfaces for examination: an anterior and a posterior, just mentioned; a superior, which is concave and smooth to receive the medulla oblongata and the basilar artery; and an inferior, which is more irregular, and which is marked as follows: from before backward, first by a median minute circular depression, not constantly present; second, by the *pharyngeal tubercle* for the attachment of the pharyngeal aponeurosis; third, by the symmetrical depressions directly in advance of the occipital condyles, for the Anterior Recti muscles. The lateral (outer) surface of the basilar portion is uneven, and articulates at its upper portion with the petrous portion of the temporal bone. Seen in position in the skull, the greater part of the under surface of the basilar process is free, and is covered by a dense fibrous tissue during life.

Each *lateral portion* is joined anteriorly by the basilar, superiorly by the ascending portion of the bone. It joins externally the mastoid portion of the temporal bone. Upon its lateral side is a deep depression, the *jugular notch* which receives the jugular vein. Directly in front of the jugular notch is seen a smaller excavation for the ninth, tenth, and eleventh pairs of nerves. At the beginning of the occipito-mastoid junction is a broad *transverse process* (jugular process), which is tipped in the recent subject with cartilage. Upon the under surface of the lateral portion, and corresponding at the same time to the under surface of the transverse process, is the *jugular tubercle*, for origin of the Rectus Lateralis muscle. Upon the under surface in front of the condyle lies the *anterior condyloid fossa*, which is pierced by the *anterior condyloid foramen* (hypoglossal canal) for the transmittal of the hypoglossal nerve. Behind the condyle is seen a depression (*posterior condyloid fossa*), which is commonly perforated by the smaller *posterior condyloid foramen* for the accommodation of the posterior condyloid vein. The superior surface of the lateral portion is marked by the lateral sinus, as it passes downward to empty into the internal jugular vein. Upon the encranial surface and over the course of the anterior condyloid foramen is seen a bridge of bone, called the *jugular eminence.*—The large *occipital condyles* are placed one on each side of the foramen magnum. The articular surface of each condyle is elliptical in form, and directed obliquely downward and inward. The anterior edge of the articular surface rests on a rounded border that is angulated to the plane of the anterior condyloid fossa and that of the basilar process. The posterior portion of the articular surface lies on a level with the posterior condyloid depression, and thus presents a marked contrast to the anterior. The inner surface of each condyle is uneven for attachment of the check ligaments. Each articular surface is composed of two facets of about equal dimensions, an anterior and a posterior. These facets are occasionally separated by a transverse groove.

The *ascending portion* of the occipital bone is a scallop-shaped expansion. It is convex externally, concave internally. The borders are thickened, and articulate by serrated surfaces with the parietal and temporal bones. The ascending portion joining

EXPLANATION OF PLATE XVI.

Fig. 1. The occipital bone, seen obliquely from the side.

Fig. 2. The occipital bone, seen from beneath.

Fig. 3. The occipital bone, seen from in front.

Fig. 4. The temporal bone, seen from beneath.

Fig. 5. The temporal bone, seen from median aspect.

The petrous portion is represented as foreshortened from in front.

Fig. 6. The temporal bone, seen from lateral aspect.

The words "Ext. Auditory meatus," should not have been engraved in capitals.

PLATE XVI

Fig 1

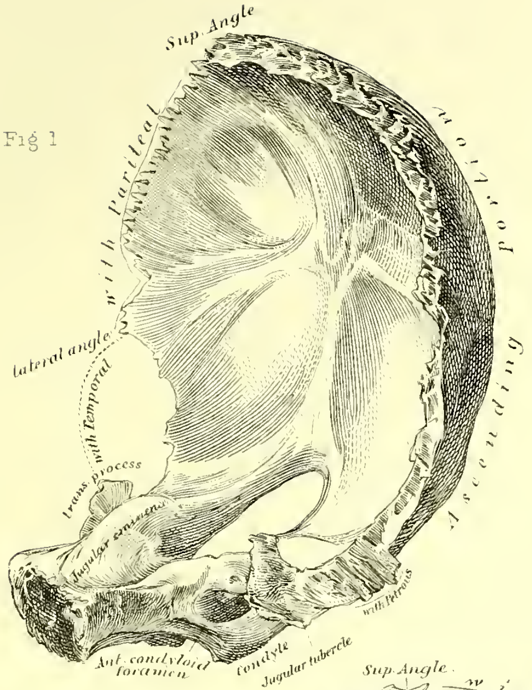


Fig 2

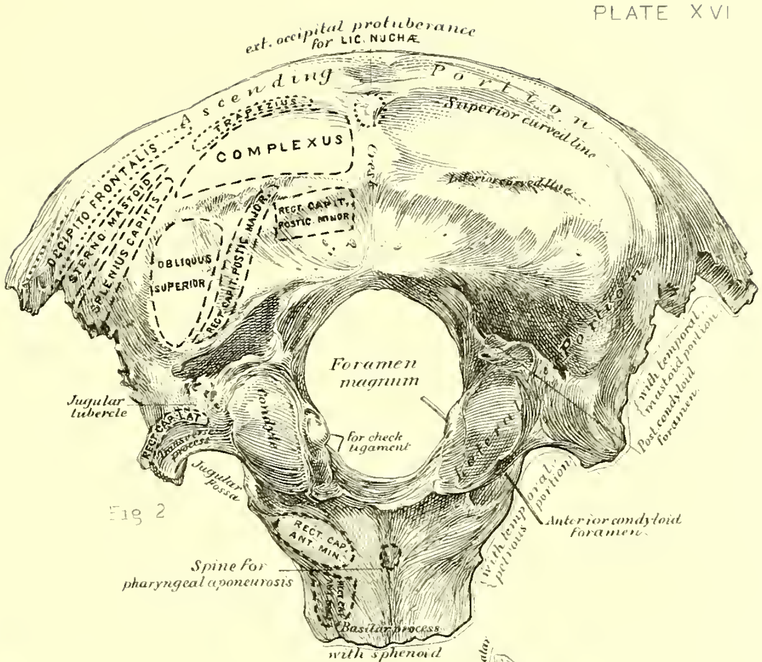


Fig. 3

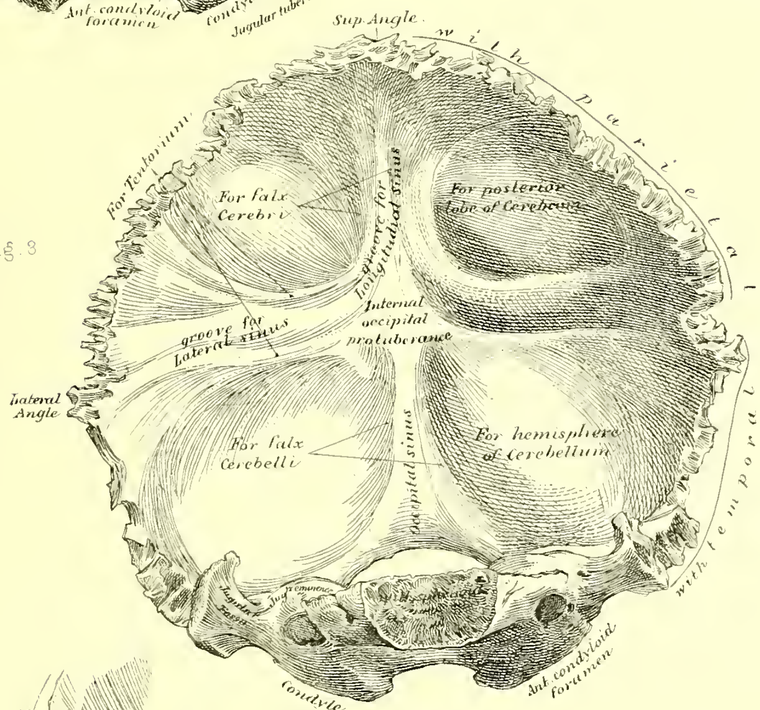
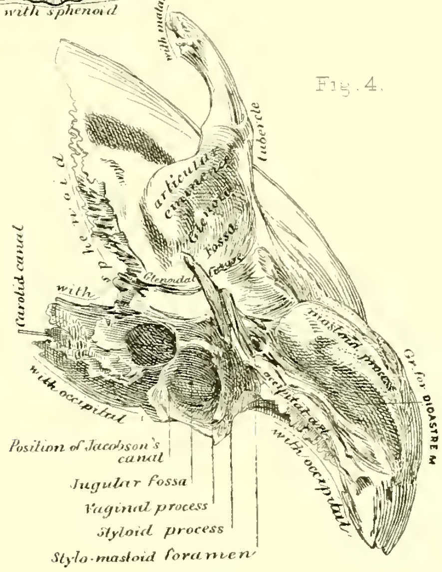


Fig. 4.



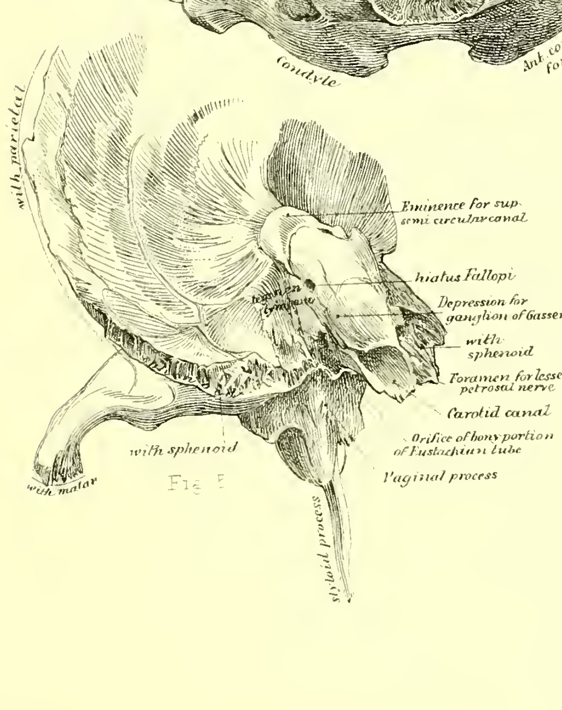
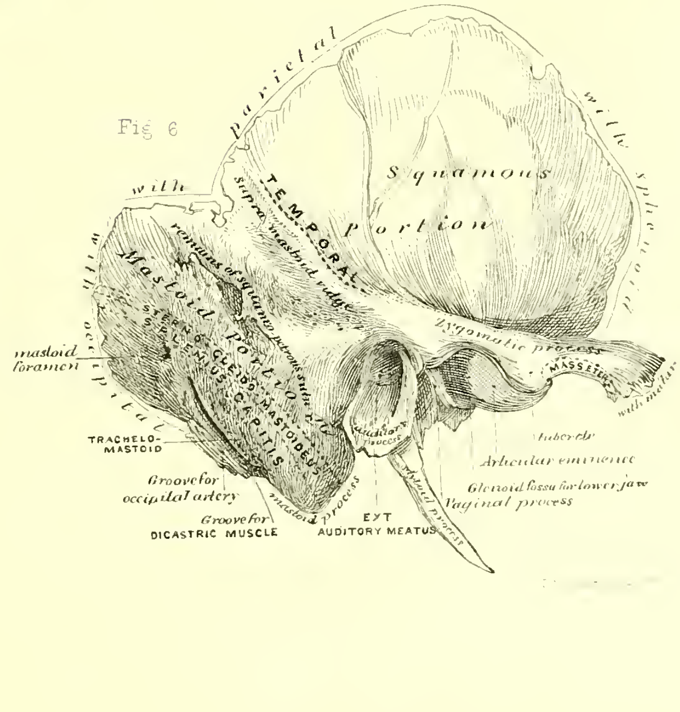


Fig 5

Fig 6



the parietals behind the sagittal suture has received the name of the occipital *angle*, and the portion occupying the space between the two parietals the *interparietal* portion. On the external surface, a little less than midway between the base and the angle, is seen the *external occipital protuberance* for the attachment of the ligamentum nuchæ. It may form a conspicuous triangular process projected downward. The surface above the protuberance is smooth, and is curved in the subject by the aponeurosis of the Occipito-Frontal muscle; the surface below it is more uneven, and is marked by muscular impressions pertaining rather to the basal region of the skull. Extending from the occipital protuberance downward is a faintly defined ridge, *the occipital crest.* On either side of the crest are strongly marked impressions for the Complexus muscles. Bordering these above lies the *superior curved line* for the attachment of the Trapezius, Occipito-Frontalis, and the Sterno-Cleido-Mastoideus muscles. On a level with the Complexus impressions, but external to them, lie the planes of origin of the Splenius Capitis and Obliquus Superior muscles. The inferior margin of the Complexus impression is known as the *inferior curved line.* The space between it and the foramen magnum is occupied by the Rectus Capitis Postici muscles.

The internal surface (fig. 3, plate XVI.) of the ascending portion is deeply concave and smooth. At a point nearly corresponding to the external occipital protuberance lies the *internal occipital protuberance.* Passing thence downward, a little to the right of the median line is seen the groove for the great longitudinal sinus as it assumes a more horizontal position to form the groove for the lateral sinus. A fainter groove on the opposite side answers to the left lateral sinus. A smaller and inconspicuous sulcus for the occipital sinus extends from the protuberance downward to the foramen magnum, in approaching which it is apt to bifurcate. The large depressions on either side of the median line above and below the grooves for the lateral sinuses form collectively the *occipital fossa.* The upper two depressions receive the posterior lobes of the cerebrum; the lower receive the hemispheres of the cerebellum.

Structure.—The basilar process of the occipital bone from the margin of the foramen magnum to nearly half its length is composed of compact tissue; beyond this point it divides into an upper and a lower plate, of which the lower is the thicker: the space between the plates is occupied by cancelli. The lateral portions are for the most part spongy, and indeed in the aged the region of the jugular process becomes hollow. The ascending portion above the superior semicircular line is thick, and furnished with abundant diploë. It is thickest toward the occipital angle. Below the internal occipital protuberance, on either side of the occipital groove, the bone is thin and compact.

Development.—The occipital bone arises from seven centres. The basilar and lateral portions exist as cartilage prior to ossification. Ossification begins at about the seventh or eighth week; thus recalling the period at which the osseous centres appear in the bodies and the laminæ of the vertebræ. A little earlier the ascending portion of the bone, which is membranous, yields four centres of ossification, two on either side. These soon unite toward the centre to form the ascending portion of the bone, but leaving pronounced fissures extending inward from the periphery. At birth the bone is composed of the ascending portion, of the lateral or exoccipital portions, and of the inferior or basilar portions. The ascending and lateral portions join at about the second and third year; the basilar and lateral portions by the fifth or sixth year. The basilar portion unites with the body of the sphenoid bone between the fourteenth and the twentieth year.

The suture between the lateral and ascending parts near the posterior border of the condyles begins to be obliterated at the end of the first year. At the end of the second the obliteration is nearly complete—a small fissure at the border of the foramen magnum often persisting until the seventh year. It is rare for the entire suture to remain open during this time. The anterior portion of the interoccipital persists quite constantly until the seventh year.

Remarks.—The occipital bone is the most variable of any in the skull. The entire interparietal portion often projects backward from the vault-curve, and constitutes a frequent variety of cranial deformity. The angular process sometimes assumes the form of a distinct bone. Portal alludes to the fact that, in injuries of the skull, this portion has been known to be depressed and to impinge upon the meninges.—A conspicuous tubercle on the anterior margin of the foramen magnum is occasionally seen. In about one per cent. of crania the odontoid process of the axis secures an articulation with a facet on the anterior margin of the foramen magnum; this facet is termed the *tertiary condyle.*—The interparietal portion may contain a large

foramen in the median line, which may be assumed to answer to defective nutritive processes at the line between the first upper pair of centres of ossification of the ascending portion.—The entire angle may be defective, and may permit a hernia of the cerebrum to occur through the opening. It is interesting to note that in a case of this kind, recorded by Detmold,[1] a median depression existed in the hernial mass; this answered in position to the falx cerebri, which thus aided in modifying the shape and limiting the degree of the projection of the hernia.

The surface occupied by the jugular tubercle is the seat occasionally of a peculiar hypertrophy, which, occupying as it does the position of the paramastoid process in the lower animals, may receive this designation. The *paramastoid process* will sometimes appear in aged persons, where, from the fact that it is occupied by a few coarse cancelli, and that it thus resembles lung structure, it has received the name of the *pneumatic process*. The presence of the paramastoid process may induce one of the varieties of wry neck,[2] especially when it is attached to the transverse process of the atlas.

That the roof of the pharynx, which in the living subject answers in position to the basilar process, can be reached by passing a straight instrument through the nose, is a clinical test easy of demonstration. Winslow refers to a charlatan's trick of introducing a long nail through the nasal chamber as far as the basilar process, and attaching to the outer end of the nail a heavy weight. The process in this trial of strength acts as a point of resistance to the extremity of the lever, and is enabled from the direction of the pressure to bear the weight.—The basilar process may be easily pierced from beneath by a missile or other foreign body introduced through the nose or mouth. Of this injury the following case is a striking example: A little girl fell down while holding a wooden crochet-needle in her mouth. The needle transfixed the uvula, passed through the basilar process directly in front of the foramen magnum, and made a punctured wound of the medulla oblongata. Death ensued in three days.[3]—Caries of the basilar process has been diagnosed by Paget[4] in a male twenty-seven years old. An abscess formed at the nape of the neck, through the cavity of which a sequestrum from about the foramen magnum was removed. Through pressure upon the hypoglossal nerve the tongue was atrophied and deflected. The patient recovered.—Dupuytren[1] describes a case in which a hydatid cyst was lodged within the hypoglossal canal, causing symptoms similar to those of the previous case.—The foramen magnum may be either compressed laterally or greatly widened. There is preserved in the Musée Dupuytren a skull of an infant in which the foramen magnum is sufficiently large to have permitted a hernia cerebelli to appear upon the neck—a fact of unusual interest, since the tumor was mistaken for a cystic growth, and opened, with a fatal result.—In rachitis, the lateral portions of the occipital bone become flattened, forming a condition termed by Elsaesser the soft occiput.—Solborg[2] found in nine cases of epilepsy a constriction of the spinal canal, from hypertrophy of the jugular process of the occipital bone and of the posterior necks of the atlas and axis, with secondary atrophy of the medulla oblongata.

[1] N. Y. Journ. of Medicine, 1856, xvi. 77.

[2] C. F. W. Uhde, Archiv für Klinische Chirurgie, 1867, 24, Tab. 1, Literature.

[3] P. I. Kendrick, Med. Times and Gazette, 1867, 585.

[4] Trans. Clin. Soc. London, iii. 283.

THE TEMPORAL BONE.

The temporal bone (figs. 4, 5, 6, Plate XVI., also fig. 4, Plate XXII.) is situated at the side and base of the cranium, having the lateral portion of the occipital bone behind, the great wing of the sphenoid in front, the axis of the cranium within, and the temporal fossa, for the most part, without. Beneath is an irregular surface marked by the mastoid, styloid, and vaginal processes, and the glenoid fossa.

The bone, as generally described, presents for examination the squamous, the petrous, and the mastoid portions, but the significance of its several divisions cannot be in this way explained. It is better to divide the bone into parts that answer to the developmental centres. These are four in number, viz., the squamous, the petrous, the tympanic, and the styloid portions. To these may be added a fifth, the mastoid portion, for although the latter is not a true division of the bone (composed, as it is, of elements obtained from the squamous and the petrous portions), it is expedient to retain the term.

The *squamous portion* (squama) is the most conspicuous of these divisions when the bone is viewed in position from without.

Externally the squamous portion is composed of the squama, or ascending part, the zygomatic or horizontal part, and the glenoid fossa. The squama forms the greater part of the temporal fossa. It is

[1] Leçons Orales, i. 493.

[2] Rosenthal, Diseases of the Nervous System, ii. 63.

received in front by the greater wing of the sphenoid bone, above by the parietal, and is limited behind by the ridge forming the posterior margin of the temporal impression, viz., the *supra-mastoid ridge.* The squama is smooth, slightly convex, and covered in the subject by the temporal muscle. The zygomatic or horizontal portion lies upon the base of the skull. The *glenoid fossa* is a depression for articulation with the lower jaw. It lies upon the base of the skull, and is defined in front by a faint ridge, behind by the *glenoid fissure* (*squamoso-tympanic suture*), and by a dependent ridge, the *post-glenoid process.* From the junction of the squamous and zygomatic surfaces arises a large process called the *zygomatic.* This has a broad triangular origin from three roots. Its large posterior root is continuous with the post-glenoid process, its short anterior root is lost in the zygomatic surface, while its third, less defined, is received upon the under surface of the base of the process in a conspicuous convexity, *the articular eminence.* The zygomatic process extends horizontally forwards to articulate with the zygomatic process of the malar bone, and to form the zygomatic arch. The Masseteric muscle arises in part from this process.

Internally, the squamous portion is concave, and marked by several inequalities designed to give increased strength to the bone. It is grooved for the meningeal arteries, and receives the middle lobe of the cerebrum. Inferiorly an eminence is seen corresponding to the glenoid fossa.*

The *petrous portion* is of an irregular pyramidal figure, the base of which is directed outward, the apex forward and inward. It is composed for the most part of very compact tissue, from which it derives its name. It contains the internal ear, transmits the facial nerve and internal carotid artery, and supports in part the cartilaginous portions of the Eustachian tube. It presents for examination three surfaces, an anterior and a posterior, which lie within the cranium, and an inferior, which lies at the base without.

The anterior surface is divided into two sub-equal areas. The upper portion is of petrous consistency, and corresponds to the bony covering of the labyrinth. It is marked as follows: (1) An eminence for the vertical semicircular canal; (2) A depression toward the apex for the ganglion of Gasser; (3) A small depression entering into the formation of the foramen caroticus internus. The lower portion is a thin layer of bone (*tegmen tympani*), which covers in the tympanum and forms the roof of the bony portion of the Eustachian tube. It is continued forward to the *squamoso-petrosal fissure*, and appears beneath at the glenoid fissure. The roof of the tympanum is perforated by one or more minute openings, the most conspicuous of which is the *hiatus Fallopii*, for the greater petrosal nerve, and a smaller one for the lesser petrosal. At times a clot of blood occupying the chamber of the tympanum will be evident (after the removal of the brain) by the bluish discoloration of the tegmen.

The posterior surface is less oblique than the anterior, and presents a division into two planes: an outer, which is marked by a small foramen directed outward, the *aquæductus vestibuli*, which transmits venous blood from the internal ear; and an inner, which is nearly continuous with the plane of the basi-cranial axis. The latter is marked by the *internal auditory meatus* for the passage of the seventh and eighth cranial nerves. Upon the ridge between the anterior and posterior surfaces is a groove for the superior petrosal sinus, which extends in a straight line as far as the *internal auditory meatus*, from which point it is deflected forward. From the meatus to the end of the petrous portion, the ridge is depressed for the reception of a thick fold of dura mater, beneath which pass the third, fourth, fifth, and sixth nerves. A distinct ossicle is occasionally found in this fold.

The inferior surface (fig. 3, Plate XXIV.) of the petrous portion is covered in part by the tympanic and styloid portions. As seen from the base of the skull, the petrous portion presents a posterior border for articulation with the occipital bone, marked from without inward by the following parts: First, by a smooth triangular surface directly behind the styloid process for articulation with the transverse process of the occipital bone. Second, by a semicircular sulcus (the *jugular groove*), which in articulation with the occipital bone forms the jugular foramen. Third, by a small notch for the reception of the ninth, tenth, and eleventh cranial nerves. Fourth, by an irregularly serrate border for articulation with the basilar process of the occipital bone, and by a small surface at its inner extremity with the body of the sphenoid bone.—The following parts are seen on the inferior free surface: First, a smooth space lying between the preceding and the inferior orifice of the carotid canal. Second, the floor of the carotid canal. To the outer side of the inferior surface is seen the large circular orifice of the canal, and to its inner side (the bone being in articulation), the median lacerated foramen. Near the basilar process of the occipital bone it is

roughened for the attachment of the pharyngeal aponeurosis; anteriorly it is smooth for the reception of the cartilaginous portion of the Eustachian tube.

The *tympanic portion* of the bone lies wholly upon its under surface. It is of an irregular shape, and composed entirely of compact tissue. When studied from without it presents a U-shaped portion wedged between the mastoid and the post-glenoid processes, limiting three sides of the large opening leading to the *external auditory meatus*, and thence to the tympanic membrane. The fourth and upper side of the meatus is formed by the squama. The curve of the U is much roughened, and produced downward. The tympanic division extends inward, and is seen on the base of the skull as a narrow compressed lamina, which insheathes the base of the styloid portion. Hence this aspect is called the *vaginal process*, which may be said to limit the glenoid region posteriorly. It is concave for the reception of the post-mandibular portion of the parotid gland. It terminates somewhat abruptly in a point opposed to the spinous process of the sphenoid bone at the beginning of the sulcus for the cartilaginous portion of the Eustachian tube. In narrow long skulls this point is often produced downwards as a spine. The floor of the external auditory meatus answers pretty nearly to the level of the base of the skull.

The *styloid portion* is composed of two separate pieces—the styloid and the tympano-hyal. The *styloid* is an elongated cylindroid spine, having an average length of an inch, and arises directly behind the vaginal process. It gives origin to the styloid group of muscles and to the stylo-hyoid ligament. The *tympano-hyal* is an unimportant ossicle placed between the base of the styloid and the stylo-mastoid foramen.—The styloid process may attain great length, when it will complicate a dissection for removal of tumors of the side of the neck.

The *mastoid portion*, seen from without, lies between the supra-mastoid ridge and the masto-occipital and masto-parietal borders. It is composed of spongy and compact tissue, and is derived from an extension outward of the primordial petrous portion joined with an outward extension of the squama. It is divided into a mastoid and a post-mastoid region by the lateral extension of the superior semicircular line of the occipital bone. The region, in great part, pertains to the occiput, with the curves of which it is continuous. Laterally, the mastoid region presents a large nipple-shaped process, the *mastoid process*, for the origin of the Sterno-Cleido-Mastoid and the Splenius Capitis muscles. In the majority of skulls an irregular depression is seen extending along the outer surface of the process. This marks the position of the primordial squamoso-petrosal suture. Behind the mastoid process lies *the digastric fossa*, for the origin of the Digastric muscle. Extending parallel with its outer side is *the groove for the occipital artery*. Above the mastoid process lies *the mastoid foramen* for the transmittal of a vein inwards to join the lateral sinus.

Medianly the mastoid division lies behind the petrous portion, and is marked with a deep broad sulcus for the lateral sinus. The union of the squamoso-parietal and masto-parietal borders exhibits a well-marked retiring angle for the posterior inferior angle of the parietal bone.

DEVELOPMENT.—The temporal bone arises both from membrane and from cartilage: the squamous and tympanic portions from the former; the petrous portion and styloid process from the latter. Ossification is first announced in the squama as early as the third month. Shortly after this the process begins in the tympanic portion. Some obscurity exists respecting the development of the petrous portion, which usually is stated to arise at about the fifth or the sixth month from a number of minute granules; but from what is seen in lower animals there appear to be three separate ossicles in the bony envelope to the labyrinth. It is probable that in man more than three definite centres exist, but that they early coalesce. At birth the temporal bone is nearly complete, the several portions having united, but the mastoid process has not appeared, the styloid is yet cartilaginous, and the auditory meatus is shallow, since the tympanic portion is as yet a mere rim of bone.

REMARKS.—The temporal bone is the seat of many pathological conditions, to appreciate which an exact knowledge of anatomy is required. M. Chassaignac[1] describes a case in which the right condyle of the lower jaw was driven into the skull by a fall from a great height upon the chin. The right condyle was found in the autopsy pressing against the middle lobe of the brain, in which was a large abscess.—Fracture of the vaginal process may ensue upon the lower jaw being driven directly backward.—But by far the greatest importance is to be attached to the complications arising from aural disease. Mr. Toynbee[2] has said: "Each of the cavities of the ear has its particular division of the encephalon to which it com-

[1] Plaies de Tété, 158.

[2] Med.-Chir. Trans., xxiv.

municates disease." A secondary inflammation may extend from the roof of the tympanic cavity to the cerebrum; from the external meatus and mastoid cells to the lateral sinus and cerebellum; and from the labyrinth to the medulla and the base of the brain. Of these the second is the most frequently seen. The mastoid cells lie in such close juxtaposition to the lateral sinus, that between the ages of eighteen and forty-five the septum is thin, and may in parts be absent, so that the lateral sinus touches directly the mucous lining of the cells. In such cases, an inflammatory process may extend from the mastoid cells to the lateral sinus, and encranial phlebitis and death may ensue. As a rule, however, inspissation of the mucus of the mastoid cells, if not suppuration and caries, precedes the meningeal complication.—The mastoid foramen has been known to discharge pus from a deep-seated abscess, as seen in the interesting case reported by Dr. F. Buszard.[1] The patient had suffered eleven months. During the latter portion of this term drowsiness and vomiting were noticeable symptoms. The bone was trephined over the position of the foramen, when the escape of viscid pus, which was believed to have formed within the cranium, followed. The patient recovered.—The petrous, the squamous, and even the tympanic portions of the temporal bone are occasionally lost by necrosis. Mr. Hinton[2] reports an instance of the exfoliation of the right tympanic bone in the course of an attack of ostitis following scarlatina in a child five years old.

P. Hewitt[3] reports a remarkable instance in which the entire bone died and was removed, with a fatal result. The case was that of a boy eleven years of age, the subject of chronic ear discharge. At the autopsy the auditory and facial nerves were seen to terminate in a bulbous mass on the dura mater. The internal carotid artery above and below could be traced as far as the walls of the cavity which had lodged the bone. The vessel was reduced to a small size, however, before it reached this spot, and was impervious.

While the temporal bone is not very vascular, as the frequency and extraordinary extent of necrosis above mentioned would indicate, severe and even fatal hemorrhage has attended the removal of bony sequestra (see account of Common Carotid Artery). Meningitis and inflammation of veins joining the lateral sinuses may also succeed necrosis of this bone.

[1] Brit. Med. Journ., 1871, 88.
[2] Trans. Path. Soc., London, 1866, 274.
[3] Med. Times and Gazette, 1864, i. 205.

The mastoid process, according to Portal,[1] is at times the seat of large syphilitic exostoses.

The space behind the ear in the living subject is sometimes called the *mastoid fossa* in clinical reports. It, however, lies for the most part above the mastoid process, and answers to the squamous surface. The term *post-auricular space* is here more appropriate. This space, together with the squama, and the portions defining the external meatus, are the only parts of the temporal bone that can be detected in the undissected subject.

THE SPHENOID BONE.

The sphenoid bone (figs. 1 and 2, Plate XVII., Plate XXIV.) occupies a central position in the head. Before it lies the face; behind it the temporal bone and the basilar process of the occipital. At the sides it joins the parietal and frontal bones, as well as the squamous portion of the temporal bone. It enters into the construction of the roof of the pharynx and nasal chambers, affords attachment to three of the four masticatory muscles, supports the superior dental arch posteriorly, forms part of the outer wall of the orbit, and the anterior and middle cerebral fossæ. It is perforated by foramina for branches of the fifth pair of nerves, the optic nerve, and the meningeal arteries.

The sphenoid bone is divided into a *body* and *three pairs of processes*, named as follows: the *lesser wings*, projecting outward from the side of the body anteriorly; the *greater wings*, from the side of the body posteriorly; and the *pterygoid processes*, projecting downward from the sides of the body beneath.

The *body* of the bone is of a quadrilateral figure, and presents for examination six surfaces, the *superior*, *inferior*, *anterior*, *posterior*, and two *lateral* surfaces.—The *superior* surface lies entirely within the brain-case. It is marked in front by the *ethmoid spine;* behind this by a smooth surface which is but faintly marked by a median elevation continuous with the crista galli of the ethmoid bone. On either side lies *a groove for the olfactory tract.* Connecting these grooves is a nearly transverse sulcus—*the optic groove*—to accommodate the optic nerves. Directly behind this groove is the *olivary process* for the support of the *optic chiasm.* The remainder of the surface is deeply concave, and forms the *pituitary fossa* (sella turcica) for the reception of the pituitary body. Limiting this fossa posteriorly is an oblique plate of bone, directed downward and backward, called the *dorsum sellæ* (clivus). When the sphenoid bone is in articu-

[1] Anat. Medical.

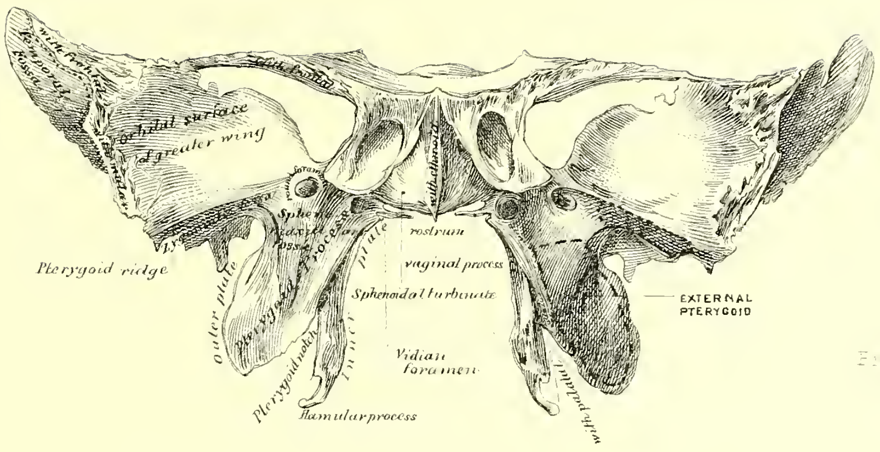
lation with the occipital, the dorsum sellæ is seen to be continuous with the upper surface of the basilar process, and aids in supporting the pons Varolii. The dorsum sellæ is composed of loose spongy tissue, and ends anteriorly by a free border, the outer angles of which are called the *posterior clinoid processes.*—The *inferior* surface is continuous with the anterior, presenting in relation to it no well-defined boundary. Conspicuous upon the surface is a triangular spine—the *rostrum*—which in articulation with the vomer fits into its upper groove. On each side is a narrow depression, covered in part by a transverse lamina—*the vaginal process*—derived apparently from the base of the pterygoid process to articulate with the alæ of the vomer.—The *anterior (nasal) surface* presents a continuation of the rostrum which here articulates with the perpendicular plate of the ethmoid bone. On each side of this median projection lies a *sphenoidal turbinated bone.* Each sphenoidal turbinated bone is defective in its upper part. It is of a triangular figure, its apex pointing downward and backward. It is a distinct bone in the infant, but soon unites with the ethmoid bone in front and the sphenoid behind. With its fellow of the opposite side it largely contributes to the formation of the sphenoidal sinus. Inferiorly the parts on each side of the rostrum are in part concealed by the apices of the sphenoidal-turbinates.—The *posterior surface* is of a quadrangular figure, which in the young subject is covered with cartilage. It articulates with the basilar process of the occipital bone. At the sides a minute process is seen which aids in forming the groove for the superior petrosal sinus.—The *lateral surfaces* of the body are almost entirely within the brain-case, a small portion only extending forward to terminate at the corresponding surfaces of the sphenoidal turbinates. Each surface presents a conspicuous depression for the internal carotid artery (*sigmoid groove*). It is better defined posteriorly than anteriorly, and along its lateral than median border. Two minute processes are detected along the course of the groove; the first and larger at the lateral border of the beginning of the groove called *the sphenoidal tongue*, and the second at the median border of the anterior end, called *the middle clinoid process.*—The *body* of the bone thus defined is hollow in the adult to form *the sphenoidal sinus.* This sinus is so often divided by a vertical septum into two that the term *sphenoidal sinuses* would be more appropriate. Clinical writers, however, invariably speak of it as a single chamber. The sphenoidal sinus communicates with the posterior ethmoidal cells, but commonly opens upon the nasal fossæ.

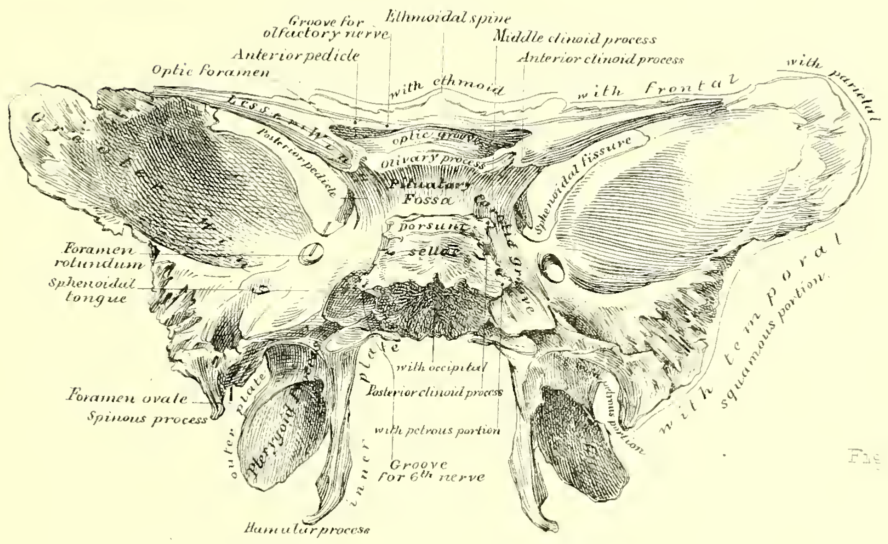
The *greater wing* of the sphenoid bone springs from the base and the hinder portion of the lateral surface. It consists almost entirely of spongy tissue. It arises by a massive base at the inferior border of the body of the bone, slightly in advance of the beginning of the carotid groove and behind the sphenoidal fissure. It is divided conveniently into a horizontal and an ascending portion.—The *horizontal portion* is smaller than the ascending. Its upper surface is marked at its outer half by a thick oblique irregular surface for articulation with the squamous portion of the temporal bone. The posterior border presents a compressed thin edge, which is slightly concave below, and forms when the bone is articulated a sulcus for the cartilaginous portion of the Eustachian tube. The under surface is smooth, and bounded externally by the *zygomatic crest.* Posteriorly the under surface terminates in a sharp process, directed downwards, termed the *spinous process.* To it is attached the internal lateral ligament of the lower jaw.—The *ascending portion* passes outward and slightly forward, and upward, to be received anteriorly by the frontal bone through a broad triangular, irregular surface at the outer side of its orbital plate, and the anterior inferior angle of the parietal bone. Posteriorly it is received by the squamous portion of the temporal bone. It is concave within to receive the middle lobe of the cerebrum. It is slightly concave without, where it is marked by two muscular impressions, one above the *pterygoid ridge* for the Temporal muscle, and the other below the ridge for the origin of the outer head of the External Pterygoid muscle. The process is smooth in front to form the *orbital surface*, and enters into the outer wall of the orbit. The orbital surface is of a quadrangular figure. It is notched at its inner surface for the passage of a branch of the ophthalmic artery. It is compact where it bounds the sphenoidal tissues inferiorly; made up of spongy tissue in the centre, it is again thin and compact

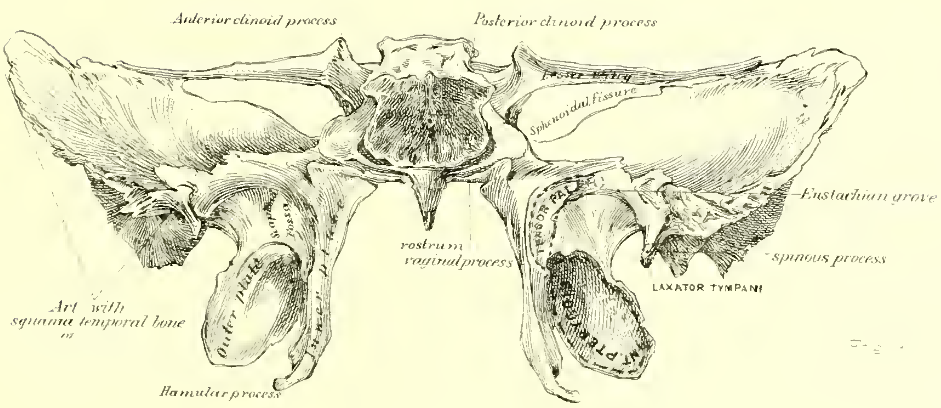
EXPLANATION OF PLATE XVII.

Fig. 1. The sphenoid bone seen from in front.
Fig. 2. The sphenoid bone seen obliquely from above.
Fig. 3. The sphenoid bone seen from behind.

PLATE XVII


with frontal
temporal fossa
orbital surface of greater wing
with frontal
with ethmoid
rostrum
vaginal process
Sphenoidal turbinate
Pterygoid ridge
outer plate
inner plate
Pterygoid notch
Vidian foramen
Hamular process
EXTERNAL PTERYGOID


Groove for olfactory nerve
Ethmoidal spine
Middle clinoid process
Anterior clinoid process
Anterior pedicle
Optic foramen
with ethmoid
with frontal
with parietal
optic groove
Posterior pedicle
Olivary process
Pituitary Fossa
Dorsum sellae
Sphenoidal fissure
Foramen rotundum
Sphenoidal tongue
with temporal squamous portion
with occipital
Posterior clinoid process
with petrous portion
Foramen ovale
Spinous process
outer plate
inner plate
Groove for 6th nerve
Hamular process


Anterior clinoid process
Posterior clinoid process
Sphenoidal fissure
Eustachian grove
rostrum
vaginal process
spinous process
LAXATOR TYMPANI
Art with squama temporal bone
outer plate
inner plate
Hamular process

where it joins the malar bone to form the spheno-temporal partition. Between the pterygoid impression and the orbital plate a well-defined groove is seen leading to the spheno-maxillary surface.

The *lesser* wing, composed of compact tissue, arises from the junction of the side with the upper surfaces of the sphenoid bone. It passes horizontally outward, and tapers as it approaches the greater wing to which at the fronto-sphenoid junction it may be attached. It possesses two pedicles. The *anterior* is thin, and lies on the same plane with the orbital part of the frontal bone. The *posterior* is stout and rounded, and is continuous with the outer edge of the olivary process medianly, and with the under thickened free border of the lesser wing laterally. The anterior border of the lesser wing is thin and serrate to articulate with the frontal bone. The posterior border is thickened and free. Its median extremity projects inward to form *the anterior clinoid process.* This process presents a median border grooved for the ophthalmic artery, and a shelving external border which overhangs the sphenoidal fissure. The opening between the anterior and posterior pedicles is the *optic foramen*, which transmits the optic nerve and the ophthalmic artery. The posterior pedicle separates the optic foramen from the sphenoidal fissure. The anterior surface of the lesser wing as it lies behind the cribriform plate of its own side sends forward a small process of bone, which aids in covering in the posterior ethmoidal cells.[1]

The *pterygoid processes* of each side descend from the junction of the body with the greater wing. Anteriorly the process forms at its upper third a smooth triangular surface, which forms the posterior wall of the spheno-maxillary fossa. The remaining portion of the process is in articulation with the palatal bone. Posteriorly the process is free along its entire border.—The pterygoid process is in great part divided into an *inner* and *outer* plate. The space between these plates, best seen from in front, is called the *pterygoid notch*, which is occupied in the skull by the pyramidal process of the palatal bone. The space between the plates seen from behind is called the *pterygoid fossa*, and gives origin to the Internal Pterygoid muscle. The *outer* pterygoid plate is broader than the inner, and is directly continuous with the outer wing. It is deflected slightly outward and forward to articulate with the palatal bone above the dental alveoli. The lower head of the External Pterygoid muscle arises from its outer surface. The *inner* plate is a compressed vertical layer of bone articulating in front with the palatal bone. The inner plate is free behind. Its inferior portion is prolonged as a hook-like extension, forming the *hamular process*, over which plays the tendon of the Tensor Palati muscle. The pterygoid fossa as it terminates superiorly is continuous with a small elliptical depression, which has received the name of the *scaphoid fossa.* It gives origin to the Tensor Palati muscle.

The Foramina of the Sphenoid Bone.—The foramina of the great wing are as follows: First, the *round foramen*, seen at the anterior third of the side of the body and directed forward. It transmits the superior maxillary branch of the fifth pair of nerves. Second, the *oval foramen.* This is a large opening in the horizontal portion of the greater wing near its petrosal border, behind and to the outer side of the round foramen. It is directed downward, and transmits from above the inferior maxillary branch of the fifth pair, and from below the lesser meningeal artery. Third, the *spinous foramen*, which transmits the great meningeal artery. The pterygoid process exhibits a canal at its base directed horizontally forward, which, transmitting as it does the great petrosal or Vidian nerve, has received the name of the *Vidian canal.* The internal pterygoid plate is marked at its base internally by a minute opening which, when the bone is articulated with the palatal, is converted into a canal known as the *pterygo-palatine canal* for the artery and nerve of the same name.

The space between the greater and lesser wings is of an irregular form, broader at the body of the bone than at the outer end, where it is narrowed to a mere chink. This space in the separate bone has received the name of the *sphenoidal fissure*, and in the skull the *anterior lacerated foramen.* It transmits the third, fourth, and sixth nerves, the ophthalmic branch of the fifth nerve, and the ophthalmic vein.

STRUCTURE.—The structure of the sphenoid bone, as already mentioned, is for the most part spongy. The greater wing with the exception of the horizontal plate is composed of thick vascular spongy tissue. In skulls that have been much weathered this tissue becomes exposed, and may be eroded to a great extent. The pterygoid process at its base, and including in great part the inner plate, is also spongy. The lesser wings are compact.

DEVELOPMENT.—The sphenoid bone develops from thirteen to fifteen centres of ossification, viz., one for each greater wing, inclusive of the external pterygoid

[1] For special description of this process in man and fox, see Luschka, Zeit. für Wissenschaft. Zool. viii., 1857, 123, Taf. iii.

process; two for the posterior portion of the body, or the basi-sphenoid; one for the anterior portion of the body, or the pre-sphenoid (this is occasionally absent); one for each of the lesser wings (these extend into and occupy the cartilage of the pre-sphenoid in the event of no separate centre arising therein); one for each of the internal pterygoid plates; one for each of the sphenoidal turbinate (three separate ossicles may be detected here); and one for each of the sphenoidal tongues.

The order in which these several centres appear is as follows: The centre for the greater wings, which appears at about the second month; the centres for the basi-sphenoid, nearly the same time; the centre for the pre-sphenoid, at about the ninth week, including those for the lesser wings; the centres for the internal pterygoid plates and the sphenoidal tongues, at the fourth month; the centres for the sphenoidal turbinates, at about puberty.

At birth the sphenoid bone is composed of three pieces—the two greater wings with the internal pterygoid plates, and the two lesser wings with the body. The greater wings join the body at the end of the first year. The sutural line of union between the pre-sphenoid and basi-sphenoid is seen as late as the third or fourth year; the turbinates join the pre-sphenoid, and the basi-sphenoid joins the occipital at puberty.

Remarks.—The greater wing of the sphenoid bone is often the seat of inflammation in strumous and syphilitic subjects. In most specimens of the sphenoid bone of the adult this portion is seen conspicuously marked with vascular foramina. The region of the pituitary fossa is occasionally the point of origin of diseased action—either within the body of the bone or within the pituitary body—which may extend laterally and involve the cavernous sinuses,[1] and the internal carotid arteries. Instances have been recorded of caries of the body eroding one of the last-named vessels and causing fatal hemorrhage.

[1] W. Moxon. Tr. Clin. Soc. Lond., v. 45.

Robert[1] mentions an instance of fracture of the body of the sphenoid bone at the sella turcica, the dura mater in contact with it being torn. The crevice thus formed had communicated directly with the roof of the pharynx during life, and the sub-arachnoid fluid had trickled through the opening into the nose, creating a watery discharge.

For additional remarks see Base of Skull.

THE PARIETAL BONE.

The parietal bone (Plate XVIII.) is of a quadrilateral figure, and is situated on the side of the cranial vault between the fellow of the opposite side, the squamous and the mastoid portions of the temporal and the great wing of the sphenoid bone below, the frontal bone in front, and the occipital bone behind.

The *anterior superior angle* is a right angle. It is developed in infancy to aid in closing the great fontanelle. The *postero-superior angle* is an obtuse angle, and assists in closing the postero-superior fontanelle. The *antero-inferior angle* is in the isolated bone the most produced of any. It forms a narrowed tongue of bone fitting in the space between the frontal and temporal bones, and articulates with the sphenoid bone. The *postero-inferior angle* is broader and more truncated than the others. It joins the mastoid portion of the temporal bone.

The parietal bone is composed of one or more layers of spongy tissue, placed between two plates of compact tissue, of which the outer is the most variable. The bone presents for examination two surfaces and four borders and angles. The bone is marked externally by a conspicuous rounded elevation, termed the parietal eminence—which corresponds to the centre of ossification. At the lower part of the external surface is seen a semicircular canal, limiting the temporal fossa superiorly. The bone is concave, and is deeply grooved by the great meningeal artery, which is directed from below upward and before backward from the antero-inferior angle. Near the upper margin of the bone

[1] Gazette des Hôpiteaux, 1840, 205.

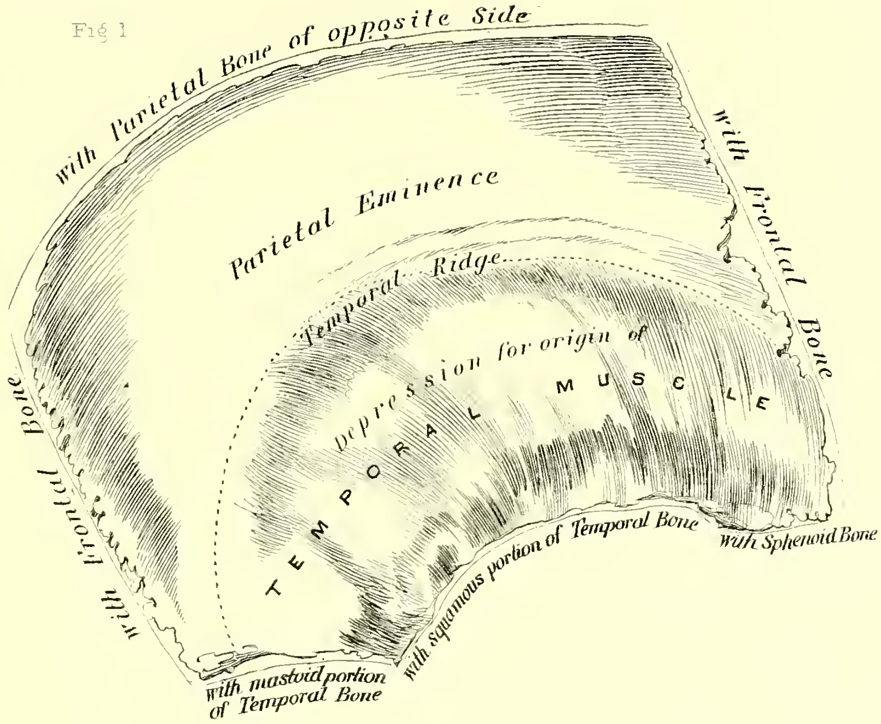
EXPLANATION OF PLATE XVIII.

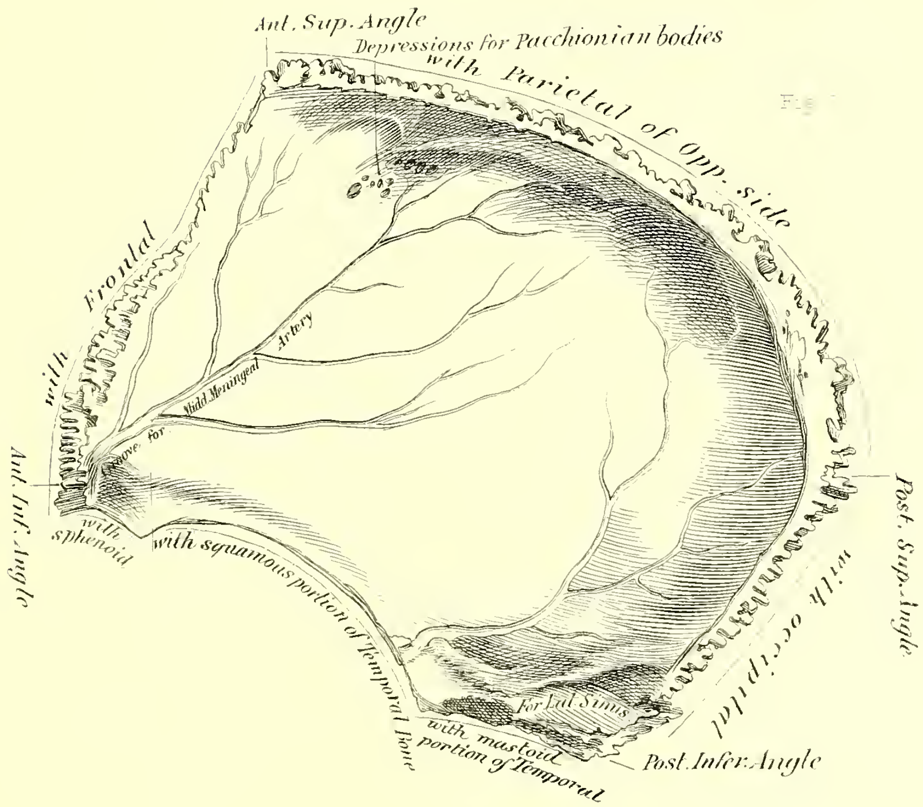
Fig. 1. The parietal bone seen from without.

For the words "with frontal bone" on left hand border read "with occipital bone."

Fig. 2. The parietal bone seen from within.

Fig 1


with Parietal Bone of opposite Side
with Frontal Bone
Parietal Eminence
Temporal Ridge
Depression for origin of
TEMPORAL MUSCLE
with Frontal Bone
with squamous portion of Temporal Bone
with Sphenoid Bone
with mastoid portion of Temporal Bone


Ant. Sup. Angle
Depressions for Pacchionian bodies
with Parietal of Opp. side
with Frontal
Groove for Midd. Meningeal Artery
Ant. Inf. Angle
with sphenoid
with squamous portion of Temporal Bone
Post. Sup. Angle
with occipital
For Lat. Sinus
with mastoid portion of Temporal
Post. Infer. Angle

are seen several shallow depressions for the Pacchionian bodies. Inferiorly and posteriorly the inner surface is grooved for the transverse sinus. The *upper*, *anterior*, and *posterior* borders are simple in character, and present coarse serrations for articulation with adjacent bones. The *inferior* border is bevelled at its anterior two-thirds for articulation with the squama —the posterior third being coarsely serrated, to articulate with the mastoid division of the temporal.

Development.—The parietal bone arises from a membranous matrix by a single centre of ossification which appears at the seventh or eighth week.

Remarks.—This bone will occasionally exhibit between the parietal eminence and the borders of the bone one or more foramina of large size. They are evidences of defective development of the part, which process would appear to be less active in the region between the centre of ossification and the borders of the bone than elsewhere. Dr. J. S. Parry[1] has associated the tendency to such a condition with rickets. Prof. Turner[2] believes these openings to be enlarged vascular foramina, for although they are occupied with membrane during life, such membrane was found by him to be perforated by minute vessels.

THE FRONTAL BONE.

The frontal bone (figs. 1, 2, and 3, Plate XIX.) is a symmetrical bone situated at the anterior part of the cranium between the parietals above, the wings of the sphenoid behind, and the bones of the face below.

It is for the most part composed of compact tissue. The bone supports the anterior half of the cerebrum within; it affords attachment to the part of the Temporal muscle at its sides, where it enters into the composition of the temporal fossa. It forms the roofs of the orbits, and receives the cribriform plate of the ethmoid bone.

The frontal bone is divided into an ascending and a horizontal portion. The *ascending portion* is marked anteriorly by the upper margins of the orbits—the *supra-orbital arches.* At the inner third of each arch is seen the *supra-orbital notch*, for the escape of the frontal branch of the ophthalmic nerve. This is sometimes converted into a foramen. The outer extremity of the arch is continuous with the external angular process; the inner extremity—more produced —forms the *internal angular process.* Between the two internal processes lies a rounded elevation—the *nasal eminence*, which forms the anterior wall of the frontal sinus.

The *frontal sinus* (fig. 1, Plate XXIII., figs. 1 and 2, Plate XXIV.) is an irregular chamber, lined with mucous membrane, situated between the inner and outer plates, at the junction of the ascending and horizontal portions. It communicates with the nasal chamber by means of the infundibulum of the ethmoid bone. The inferior surface is irregularly serrate for articulation with the ascending process of the superior maxillæ, the nasal bones, and the vertical plate of the ethmoid. A conspicuous median process of the frontal bone—the *nasal spine*—is firmly wedged between these bones. Extending from the base of the process upward along the median line are seen the remains of the frontal suture. Upon either side of the frontal suture is the circular *frontal eminence*, and below each eminence the *supra-ciliary ridge*, which corresponds pretty nearly with the supra-orbital arch of its own side. Laterally the ascending portion is marked by a muscular impression, called the *temporal ridge*, which limits the anterior third or fourth of the temporal fossa. Between this ridge and the supra-orbital arch is produced the external angular process, a conspicuous mass of spongy tissue articulating with the malar bone and the greater wing of the sphenoid bone. The *posterior*, or encranial surface, is smooth for the reception of the anterior lobes of the cerebrum. In the middle line is seen a deep narrow sulcus, narrower below than above, for the great longitudinal sinus. Inferiorly in front of the ethmoidal notch the sulcus ends in a minute opening, the so-called *foramen cæcum.* This opening is continuous in childhood with the nasal chambers, and transmits a small vein. In the adult it is closed, and is occupied by fibrous tissue.

The *horizontal portion* is composed of the two *orbital plates* and the *ethmoidal notch.* The *orbital plates* are two thin laminæ, which, as already said, form the roofs of the orbits without and the floor of the anterior cerebral fossa in the main within. The orbital surface is smooth save at the anterior portion of the median half, where it is marked by a minute process for the tendon of the Superior Oblique muscle. Behind the external angular process the orbital plate accommodates the lachrymal gland. The encranial surface is more uneven than the orbital, and slopes gently toward the ethmoidal notch. Each plate is marked by two or three irregular elevations forming several shallow depressions, which, from the fancied resemblance they are thought to bear to the impressions

[1] Amer. Journ. Med. Sci., Jan. 1872, 43.

[2] Edinburgh Royal Soc. Proc., v. 1877, 444.

made by finger-tips upon some yielding substance, have received the name of the *digital depressions*.

The *ethmoidal notch* is designed for the reception of the cribriform plate of the ethmoid bone. Its sides exhibit numerous irregular cell-like depressions, which assist when the bone is in articulation to form the ethmoidal cells.

DEVELOPMENT.—The frontal bone arises from membrane by two centres of development, one on either side of the median line. These centres appear near the orbital arches at the seventh week. The bone is composed of two pieces at birth. The suture between the right and left halves is called the *frontal suture*, and is in the line of the interparietal or sagittal suture. It is commonly obliterated at about the third year. The occasional persistence of this serrate suture is a subject of more than passing interest. Surgeons have been known to confound such a suture with a line of fracture.[1]—Authorities vary with respect to the time of development of the frontal sinus. Albinus described the sinus as existing in the fœtus of nine months. Blumenbach[2] and Henle believe it to be formed at the end of the second year. Its development would appear to be variable, and to be retarded by some diseases, among which may be mentioned rickets, scrofula, and hydrocephalus.

Development of the bone may be varied by the appearance of accessory centres upon the orbital plates. These frequently remain separate from the rest of the bone, resembling in their independent position the Wormian bones. Joh. Czermak[3] has described six cases of such abnormally constituted orbital plates.

REMARKS.—From want of proper union of the halves of the frontal bone hernia cerebri has been known to occur at the frontal suture.—Mr. Shaw exhibited before the Pathological Society of London an encephalocele removed from the head of an infant. The mass had projected through an opening in the frontal bone at the root of the nose, between the sutures uniting the frontal, ethmoid, and nasal bones.[1]—The frontal bone will yield occasionally small exostoses. These are sometimes of extraordinary compactness, and involve the median portion, as well as the orbital plates.—The frontal bone is infrequently fractured where it is most convex, as at the frontal and nasal eminences. It is relatively often fractured at the sides where the bone enters into the composition of the temporal fossæ, notwithstanding that in such locality the bone is protected by the Temporal muscle and aponeurosis.—The external angular process of the frontal bone frequently presents upon its orbital aspect, and thence to the roof of the orbit, a patch of foramina. In the same locality a cribriform exostosis has been occasionally observed.

The outer (anterior) wall of the frontal sinus has been removed for the extraction of polypi growing from the mucous membrane lining the sinus.[2] In a case mentioned by Jno. Bell,[3] the polypous tumors pressed the inner wall of each orbit outward, while the posterior wall was pressed backward.

Owing to the continuity of the frontal sinus with the nasal chamber larvæ of insects can readily pass from the latter to the former. Numerous cases of this condition have been observed, chiefly in tropical countries.

The size of the frontal sinus is subject to great variation. Usually confined to the frontal eminence or the space continuous thence with the supraorbital arches, it may extend over the entire length of supraorbital arches. It is apt to increase in size with advancing years. Under the influence of diseased action the frontal sinus may be obliterated, as in syphilis. One half of the sinus is apt to be larger than the other. Richet candidly mentions an expe-

[1] Velpeau, Anat. Chirurg., 228.
[2] History and Diseases of Bones, etc., Göttingen, 1786, 101.
[3] Zeitschr. für Wissenschaft. Zool., iii. 27, pl. 2.

[1] Trans. Path. Soc. of Lond., 1858, 2.
[2] Lancet, 1859, ii. p. 634.
[3] Principles of Surgery, iii. p. 134.

EXPLANATION OF PLATE XIX.

Fig. 1. The frontal bone seen from the side.

Fig. 2. The frontal bone seen from beneath.

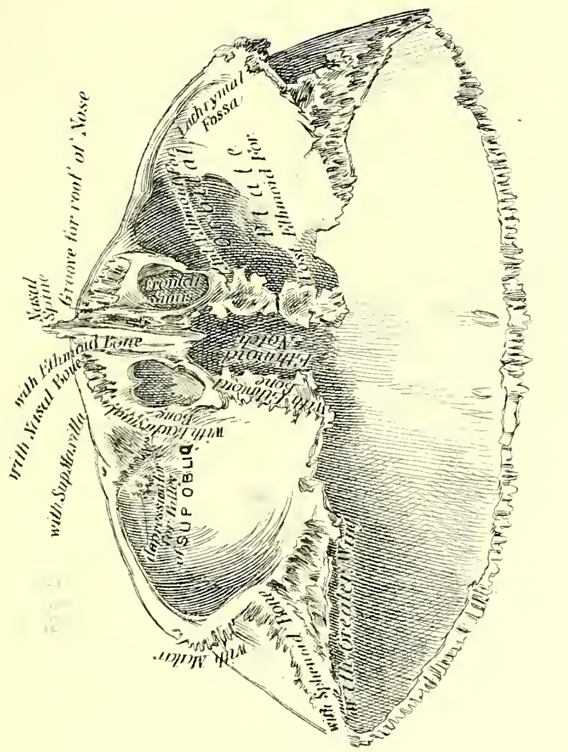
A leader should be drawn from the words "with Sup. Maxilla" to the surface directly behind the one for articulation with the nasal bones.

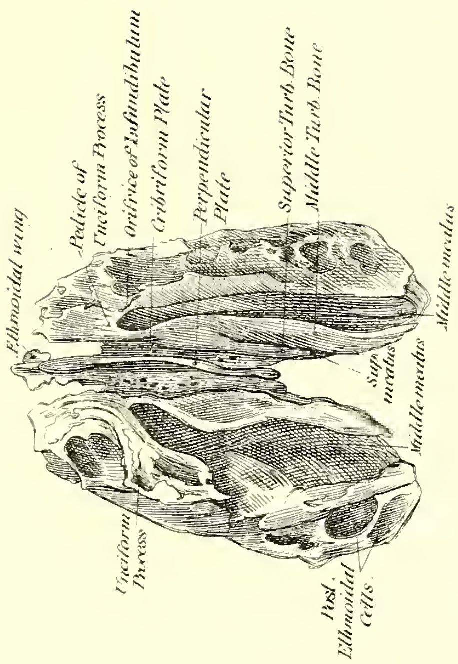
Fig. 3. The frontal bone seen from in front.

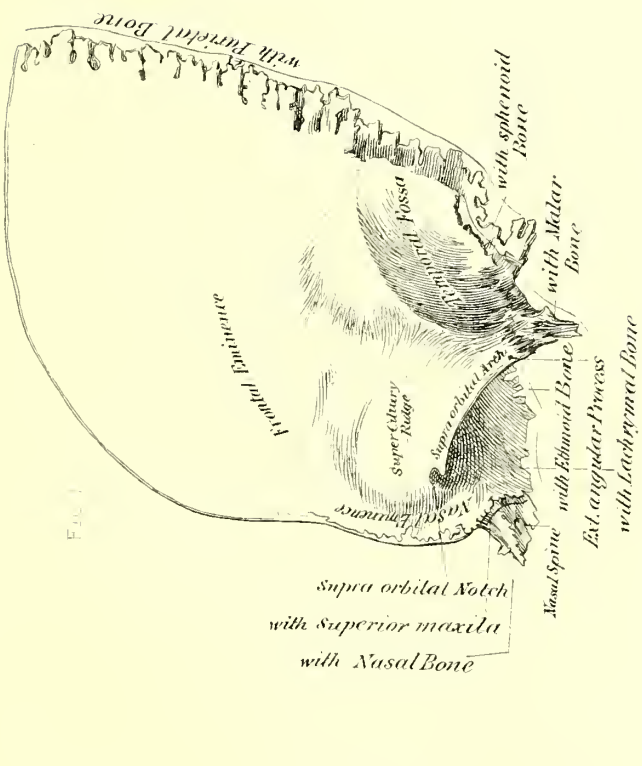
Fig. 4. The ethmoid bone seen from beneath.

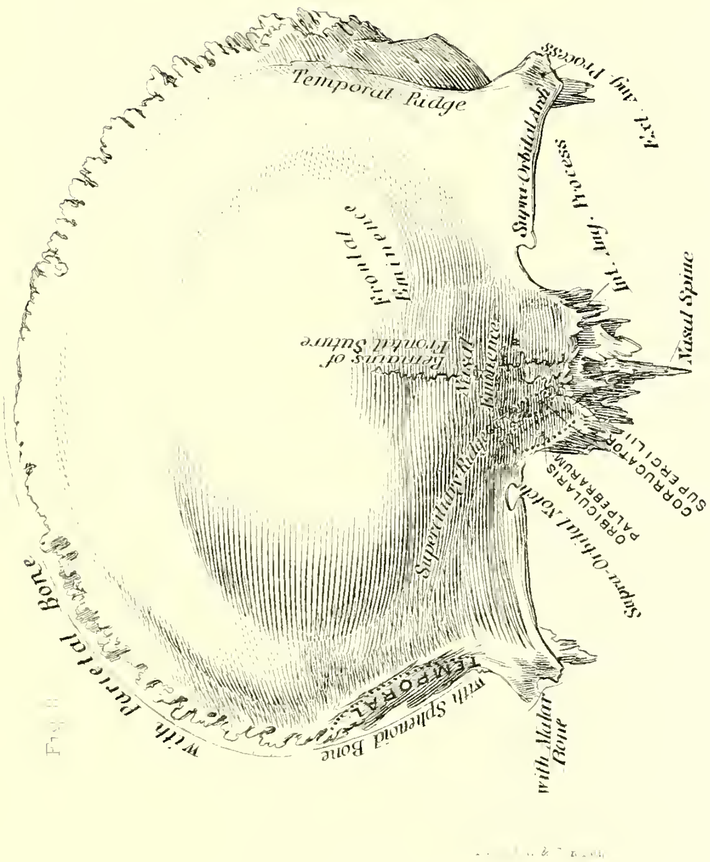
For "Unciform Process" read "Uncinate Process."

PLATE XIX


Nasal Spine
Groove for roof of Nose
Frontal Sinus
Lachrymal Fossa
with Ethmoid Bone
with Nasal Bone
with Sup. Maxilla
with Lachrymal Bone
with Ethmoid Bone
Ethmoid Notch
SUP. OBLIQ.
with Malar
with Sphenoid Bone
with Greater Wing


Ethmoidal wing
Pedicle of Unciform Process
Orifice of Infundibulum
Cribriform Plate
Perpendicular Plate
Superior Turb. Bone
Middle Turb. Bone
Middle meatus
Sup. meatus
Middle meatus
Unciform Process
Post. Ethmoidal Cells


with Parietal Bone
with sphenoid Bone
with Malar Bone
Temporal Fossa
Frontal Eminence
Super Ciliary Ridge
Supra orbital Arch
Nasal Eminence
Nasal Spine
with Ethmoid Bone
Ext. angular Process
with Lachrymal Bone
Supra orbital Notch
with Superior maxila
with Nasal Bone


Temporal Ridge
Ext. Ang. Process
Supra Orbital Arch
Int. Ang. Process
Nasal Spine
Frontal Eminence
Remains of Frontal Suture
Nasal Eminence
Superciliary Ridge
SUPERCILII
CORRUGATOR
ORBICULARIS PALPEBRARUM
Supra-Orbital Notch
with Malar Bone
TEMPORAL
with Sphenoid Bone
with Parietal Bone

rience of his own in which he for a time mistook such an asymmetrical growth for an exostosis.

From the extreme thinness of the orbital plates a slight direct blow will break them. This has actually occurred in more than one instance. Inconsiderable and sometimes undetected external wounds, from such objects as tobacco-pipe stems, and tips of umbrella sticks, have been associated with fracture of the orbital plate and cerebral injury.[1]

Abscess of the frontal sinus will expand the walls and cause outward inclination of the inner aspect of the orbit above the os planum of the ethmoid. A patient under the care of Mr. Soelberg Wells,[2] showing these peculiarities, had, in consequence of periocular infiltration as well as from the direct pressure of the abscess, protrusion of the right eyeball.

THE ETHMOID BONE.

The ethmoid bone (fig. 4, Plate XIX.; fig. 1, Plate XX.)—while properly a cranial bone, inasmuch as it enters into the construction of the brain-case—lies for the most part within the region of the face. Like the sphenoid bone, it is strictly symmetrical; and is composed of a median portion which receives the name of the *vertical plate*, and two *lateral portions* or *masses*. Uniting the vertical plate and the lateral masses is the *horizontal* or *cribriform* plate. The entire bone is of a cuboidal figure, and aids in defining the floor of the anterior cerebral fossa, the nasal chambers, and the inner wall of each orbit. The nasal surfaces of the ethmoid are covered with mucous membrane that accommodates the organ of smelling.

The *vertical plate* (meso-ethmoid) is a thin lamina of bone in the median line extending downward from the cribriform plate into the face, and upward from the cribriform plate into the brain-case. The downward extension is vastly the larger of the two, and has received the name of the *perpendicular plate* of the ethmoid bone. It constitutes the upper third of the nasal septum. Its anterior boundary is inclined forward, and articulates with the nasal spine of the frontal and the crest of the nasal bones. The posterior border joins the sphenoidal crest of the sphenoid bone. The inferior border is obscurely angulated: the portion sloping upward and forward in front of the angle articulates with the triangular cartilage of the nose, while the portion back of the angle articulates with the vomer. The sides of the vertical plate are grooved for the olfactory nerves.

[1] Dublin Journ. of Med. Sci., xi. p. 353.

[2] Lancet, 1870, p. 694.

The upward extension of the vertical plate forms a robust angulated ridge, ivory-like in appearance, which has been named, from its assumed resemblance to the cock's comb, the *crista galli*. Seen from the cranial surface, the *crista galli* appears to arise from the horizontal plate. Its anterior border is nearly vertical, and is provided at its base with two symmetrical flanges—the so-called *ethmoidal wings* or *alæ*. The great longitudinal fold of the dura mater is attached to the crista galli.

Each *lateral mass* (ethmo-turbinate bone) is of a cuboidal figure, and presents, therefore, six surfaces for examination. Of these, the *superior* and *inferior* are imperfectly defined; the former being composed of irregular cellules that are covered in and completed by the frontal bone; the latter, being part of the complicated median surface, can be described in connection therewith.

The *median* or *nasal* surface (fig. 2, Plate XXIV.) is of great complexity. It is defined by a lamella that arises from the cribriform plate and descends at its anterior third to the inferior border without interruption. At its origin anteriorly it is continuous with the pedicle of the uncinate process, and posteriorly with the spheno-turbinated bones. At its posterior two-thirds, the nasal surface is interrupted by a large horizontal sulcus, called, from its relations to the topography of the nasal chamber, the *superior meatus*. It is continuous with the posterior border of the bone which it deeply notches. All that portion of the bone lying between the cribriform plate and the upper margin of the sulcus is called the *superior turbinated bone*, and all that portion between the lower border of the sulcus and the lower margin of the nasal surface is called the *middle turbinated bone*. The middle turbinated bone is scrolled outward, and constitutes the most conspicuous feature on the *under* surface of the bone. Directly to the outer side of the middle turbinate lies the large sulcus, known, when the ethmoid is articulated with its associate bones, as the *middle meatus*. The entire median surface of the ethmoid is minutely roughened and pitted by the delicate canals and openings of exit of the olfactory nerves.

Arising in common with the anterior margin of the median surface, to which it may be regarded as an appendage, is the *uncinate process* or *process of Blumenbach*. This is an irregular lamina extending downward, outward, and backward—lying at first to the median side of the ascending process of the superior maxilla, and then to the median side of the lachrymal. The uncinate process articulates with the ethmoidal process of the inferior turbinated bone,

and aids in closing the orifice of the maxillary sinus.

The *lateral* or *outer* surface of the lateral mass is nearly smooth. Its anterior portion is cellular, and is covered in by the lachrymal; the remaining portion forms the median wall of the orbit, and, from its uniformly smooth appearance, has received the name of the *os planum* (fig. 1, Plate XXIV.). Two grooves at the upper margin of the os planum transmit ethmoidal branches of the ophthalmic nerve. The thin *posterior* surface joins the sphenoid.—The space between the median and lateral surfaces of the lateral mass is occupied by the superior meatus and a number of open spaces lined with mucous membrane which have received the name of the *ethmoid cells.* Two sets of these cells are described, viz., the anterior and the posterior. The posterior set of cells opens upon the superior meatus, while the anterior cells are continuous with the frontal sinus by means of a passage known as the *infundibulum.* Inferiorly, the anterior cells communicate with the middle meatus.

The *cribriform plate* or *lamella* (fig. 1, Plate XXIII.) unites the cranial surfaces of the lateral masses and the vertical plate. Strictly speaking, there are two cribriform plates, one on each side of the *crista galli.* Each plate receives the olfactory bulb of its own side —hence it is sometimes called the *olfactory sulcus*— and transmits the olfactory nerves arising from its under surface. The numerous openings of the cribriform plate are arranged without apparent order. They are for the most part the orifices of obliquely-placed short canals. Directly behind the ethmoidal wing lies a narrow slit-like opening for the nasal branch of the ophthalmic nerve.

STRUCTURE.—The ethmoid bone is composed of delicate lamellæ of varying degrees of thickness. The thickest portions of the bone are the crista galli —which is occasionally hollow—the wings, and the pedicle of the uncinate process.

ARTICULATION.—The ethmoid bone articulates by the perpendicular plate with the vomer; the lateral masses with the frontal, sphenoid, nasal, lachrymal, superior maxillary, and palatal bones, and by the uncinate process with the inferior turbinated bone.

DEVELOPMENT.—The ethmoid bone arises from three centres of ossification, one for each lateral mass, and one for the vertical plate. The orbital plates begin to ossify in the fourth or fifth month; the vertical plate and the cribriform plate within the first year. The bone is complete at the fourth or fifth year.

REMARKS.—For detailed clinical application of the anatomy of the ethmoid bone, see Nose. The cribriform plate can be readily fractured by instruments thrust upward from within the nasal chamber, and the brain thus penetrated. After such a method infanticide has been committed. It is asserted that the ancient Egyptians removed the brains of their dead through such an opening prior to subjecting the bodies to the embalming process. A case has been reported[1] having for conspicuous features a fracture of the cribriform plate, a punctured wound of the brain, and a foreign body, in the shape of the ferule of a fencing cane, lying at the side of the clinoid processes of the sphenoid bone. While engaged in a friendly exercise at fencing, the patient had received a thrust from his opponent, which had entered the nose and passed with but little opposition through the cribriform plate to the middle of the base of the skull (compare fig. 2, Plate XXIV.). Operation upon the nasal chambers, as, for example, the removal of a polypus by evulsion, has in more than one instance been followed by inflammation of the soft parts overlying the cribriform plates. When the olfactory nerve is absent, as in cyclops monsters, the olfactory foramina of the cribriform plates are absent also. Cerebral hernia has occurred through the cribriform plate into the nasal chamber.[2] Retzius refers to a case of simple congenital meningocele at the root of the nose in a woman aged twenty-five.

THE VOMER.

The vomer (fig. 2, Plate XX.) is a thin rhomboidal lamina of bone situated in advance of and beneath the body of the sphenoid and between the nasal chambers. It presents for examination an anterior, posterior, superior, and inferior border, and a right and a left surface. The *anterior* border is oblique from above downward and from behind forward to articulate with the perpendicular plate of the ethmoid bone and the triangular cartilage. The *posterior* border is shorter than the anterior, and is free. It serves to separate the posterior nares from each other. The *superior* border presents a V-shaped depression for articulation with the rostrum of the sphenoid bone, and is furnished with stout everted lips, termed the *wings of the vomer* (alæ). The lateral edge of each wing unites with a thin lamina from the internal pterygoid process of the sphenoid bone and the sphe-

[1] Dublin Journ. of Med. Sci., xi. 349.

[2] Velpeau, Chirurg. Anat., i. 104; Spring, Hernie du Cerveau, Brussels, 1855.

noidal process of the palatal bone. In carefully macerated specimens of the vomer a small ridge is seen, which limits the plane of the posterior nares superiorly. The *surfaces* of the vomer are smooth save where they are grooved for the naso-palatine vessels and nerves.

STRUCTURE.—The vomer is composed of two layers of bone, which slightly diverge at the anterior border. In fresh specimens there is found in the groove in this way formed a thin rod of cartilage, which is continuous with the triangular cartilage.

ARTICULATION.—The vomer articulates with the sphenoid, ethmoid, palatal bones, and the superior maxillæ, and with the triangular cartilage.

DEVELOPMENT.—The vomer arises from the perichondrium of the septal cartilage by a single centre of ossification.

REMARKS.—The vomer presents the following variations: The two layers composing the bone are very distinct—an evidence of unusual degree of persistence of the septal cartilage. The wings may be greatly exaggerated—recalling exostoses. The wings may be very small, and the groove between the plates anteriorly occupied by calcified cartilage.

THE SUPERIOR MAXILLA.

The superior maxilla (figs. 3 and 4, Plate XX.) occupies the space between the orbit and the mouth—the zygomatic fossa laterally, and the outer wall of the nose medianly. It assists in forming the floor of the orbit, the outer side and floor of the nose, and the anterior nares, and affords lodgment for the upper teeth.

It presents for examination a central portion or body, and the nasal, palatal, malar, and alveolar processes.

The boundaries of *the body* correspond pretty accurately to the shape of a large cavity—*the maxillary sinus*. The antero-posterior section of the body bisects the sinus at the position of the first molar tooth. The sinus is of a triangular figure. One side of the triangle forms the floor of the orbit; another, imperfect one, the nasal side; while between the nasal and the orbital borders lies the facial. In a horizontal section of the body the posterior border is seen to be convex and directed towards the zygomatic fossa, hence the name given it of *the zygomatic surface*. The size of the maxillary sinus is subject to great variation. It may extend into the malar bone. It is occasionally divided into compartments by incomplete vertical septa.

The *orbital* surface of the body is a nearly smooth plane, and is slightly oblique from within outward. Its inner edge articulates with the lachrymal bone and the os planum of the ethmoid. Its outer edge joins the malar bone at its anterior half, and forms the inner border of the spheno-maxillary fissure at its posterior half. The orbital surface is marked by a groove running from behind forward, which terminates in a canal near the front edge. This is the *infra-orbital groove and canal* for the transmission of the infra-orbital nerve and artery. The orbital surface may serve to cover in the nasal chamber above the middle meatus.

The *inner* or *nasal* surface is imperfect. It presents an upper and a lower plate, with a large irregular opening between them. When the bones of the face are in position, this opening is partially closed by the palatal bone, the ethmoidal process of the inferior turbinated, and the uncinate process of the ethmoid.

The *lateral* or *facial* surface is concave, and extends from the root of the malar process forwards to the median line at the anterior nasal aperture. Its junction with the orbital plate is marked by a thickened border—the *infra-orbital ridge*—which is continued a short distance upon the ascending process. Directly below the ridge lies the *infra-orbital foramen* for the nerve and artery of the same name. Extending from the infra-orbital foramen to the alveolar process, to the outer side of the eminence of the socket for the root of the canine tooth, is a depression known as the *canine fossa*. To the median side of the canine depression lies the *canine eminence*, answering in position to the root of the canine tooth. Above the incisor teeth is seen a smaller depression—the *myrtiform fossa*.

The *posterior* or *zygomatic* surface is convex. It extends from the base of the malar process to the nasal aspect of the bone, where it joins the vertical plate of the palatal bone. It is separated from the orbital surface of its own bone by a sharp line at the inner border of the spheno-maxillary fissure. The zygomatic surface presents a rounded eminence above the alveolus for the last molar tooth, termed the *tuberosity*. Above it a short distance lie the *posterior dental foramina* for the transmission of the posterior dental artery and nerves. This surface presents medianly an articular surface for the pyramidal process of the palatal bone.

The *nasal process* is the stoutest in the region of the face. It is broader below than above, and is inclined upward and slightly backward to articulate

by a broad, jagged extremity with the frontal bone. The origin of the nasal process is best seen from within the nasal chamber; it here presents a smooth concave surface defined in front by the sharp compressed edge of the outer border of the anterior nasal aperture, and behind by the thickened anterior border of the lachrymal groove. This border is traceable upward to appear at the outer aspect of the bone on the inner wall of the orbit in front of the lachrymal bone, so that the lachrymal groove lies upon the inner side of the nasal process below and terminates at its outer side above. The nasal process is marked within by two *transverse ridges*, the lower for the inferior turbinated bone, the upper for the middle turbinated. The outer or facial surface may be divided at the level of the infra-orbital ridge into an upper and a lower portion. The upper portion is slightly concave externally, and marked by minute depressions thought to be traces of the development of the bone. Its anterior edge is articulated with the nasal bone. The infra-orbital ridge is here observed to be continuous with the anterior border of the lachrymal groove.

The *palatal process* is a horizontal plate of bone extending the entire length of the oral aspect of the superior maxilla. It is thinner at its middle than at either border. It is best defined opposite the second molar tooth, where it arises from the alveolar process and presents a thin transverse border for union with the palatal process of the palatal bone. It joins its fellow of the opposite side at the median line by a vertically serrate border; the upper edge of which, termed the *crest*, is produced to articulate with the vomer. The internal border of the palatal process is broader in front than behind, and it is continuous with the mesial border of the alveolar process at about the site of the *anterior palatine canal.* This foramen is best seen from beneath when the superior maxillæ are in position. It then presents an ovoidal depression, at the base of which is seen the median suture. Lying within this depression are the two minute *naso-palatine canals.* At its sides are seen the *incisorial foramina.* These two sets of canals transmit the terminal branches of the naso-palatine nerves from the nasal chambers to the roof of the mouth. The palatal process is smooth and concave above to enter into the floor of the nose, and roughened below for the attachment of the mucous membrane of the roof of the mouth. The lateral border of this surface is grooved for the posterior palatine artery and nerve.

The *alveolar process* extends along the under margins of the facial and zygomatic surfaces. It is a stout curved mass of spongy bone, placed at the sides of the hard palate and curved forward at the incisorial region to join its fellow of the opposite side at the median line. It is well defined within the cavity of the mouth, where it forms an angle with the palatal process. On the facial and zygomatic aspects it is continuous with the body of the bone. The alveolar process is divided into eight sockets or alveoli, corresponding in size and shape to the teeth; those of the molar teeth being broad, the canine circular, and the incisors somewhat compressed from side to side. The bases of the sockets of the roots of the first and second molars appear as eminences within the maxillary sinus. That of the canine tooth is the deepest, and forms the canine eminence on the facial border.

The *malar process* is broad, and is seen at the junction of the facial and zygomatic surfaces. It is directed horizontally outwards, and articulates with the malar bone.

STRUCTURE.—The body of the superior maxilla is composed of thin laminæ. The ascending process is compact, but the alveolar process is made up entirely of small-meshed but stout cancelli.

ARTICULATION.—The superior maxilla articulates with the bone of the opposite side, the frontal, nasal, ethmoid, lachrymal, palatal, malar, and inferior turbinated bones, as well as with the vomer. It also joins the triangular cartilage.

DEVELOPMENT.—Our knowledge of the development of the superior maxilla is in a less satisfactory state than that of any other bone. Its centres appear in membrane and soon coalesce. Writers agree, however, that separate centres appear in the alveolar arch, the nasal, facial, orbital, and malar portions. Inferences deduced from the study of comparative anatomy and structural defects lead us to believe that the incisorial portion arises from two centres of ossification, one on either side of the median line in the position of the premaxillæ of lower animals. Development begins as early as the sixth or seventh week. In complete cleft palate the incisorial portion is separated from the remaining portion of the bone of the side corresponding to that on which the cleft occurs, or on both sides if the clefts in the alveolar arch are double (bilateral). Moreover, grave lesions in the development of the face indicate that the lateral parts of the superior maxilla arise within the first pair of visceral arches, while the incisorial centres arise within the lower free edge of the median fronto-nasal process of the embryo which descends in front of the ethmo-vomerine septum.

When the premaxillæ unite at the median line, the pair may be denominated the *intermaxillary bone.* The suture between the premaxillæ may be detected until the sixth year, and on the hard palate as late as the adult period.

REMARKS.—In diseased conditions the identity of the premaxilla is occasionally established. Mr. Hughlings Jackson[1] describes the case of a boy three years of age who suffered from severe inflammation of the mouth followed by the exfoliation of the right premaxilla, the maxilla proper not being affected. The bone contained two incisor teeth. Mr. Bryant[2] gives an instance of the same disease in an adult aged forty-four, from whom an exfoliation was secured which corresponded to the premaxilla.

The following is an exceedingly interesting case in this connection which came under the notice of the writer: A gentleman, aged sixty, was much annoyed by a defect which prevented his dentist fitting a plate for artificial teeth. The patient was edentulous, and had had from early childhood a cleft in the incisorial portion of the upper jaw, which, as he had been informed by his parents, was caused by the loss of bone following an attack of measles. The cleft was a little to the right of the median line, and extended upward to the floor of the nose and backward along the roof of the mouth about an inch. The sides of the cleft were for some distance in contact, but posteriorly a delicate probe could be introduced into the nose. The entire right side of the dental arch was more incurved than the left. Acquired malformation of the hard palate, the result of early loss of the left premaxilla, was diagnosed.

The fact that both upper and lower maxillæ are derived from membrane would apparently explain the rarity of cartilaginous tumors, and would equally make clear the meaning of the fact expressed by Agnew[3] as follows:—

"Fibrous tumors of the upper jaw are quite uncommon, although frequently met with in the lower maxilla. A considerable proportion of all the morbid growths of the lower jaw belong to this class."

The case described by Mr. Hutchinson,[4] in which a cartilaginous tumor of the upper jaw occupied the canine fossa, but did not grow from the bone, must be considered in every way anomalous.

The law of symmetrical distribution of diseased action is not without example in the upper jaw, though instances of it are rare. The cases of Lebert and Murchison (see the section on the Lower Jaw) also included lesions of the upper jaw. Fergusson,[1] in commenting on a case of tumor in the alveolus and median line of the upper jaw, says that disease in one maxilla is common, but it is rare to find it implicating both maxillæ.

Many diseases of the superior maxilla take their origin from the mucous lining of the maxillary sinus. A tumor growing in all directions from the sinus will encroach within on the nasal chamber, above on the orbit, without and forward on the face, and downward into the mouth. The most common form of distortion, or at least the most noticeable, is the obliteration of the canine fossa. At times the bone becomes thinned, and will crackle under the finger like a piece of parchment. In a case mentioned by C. H. Moore,[2] a tumor of the right superior maxilla, of about two years' duration, formed about the position of the canine fossa, where a conspicuous thinning of the wall ensued. This eventually gave way, and the fluid contained in the sinus escaped into the mouth. In other instances, the collection will open upon the cheek, as described by J. H. Howard.[3] At a later stage of cystic distension, the entire anterior wall of the sinus may bulge forward and give rise to deformity. After the anterior, the most yielding wall of the sinus is the orbital. As a result of pressure in this direction, the eyeball may be displaced and protrude, the conjunctiva becoming thickened and inflamed. Pressure toward the nose and toward the hard palate is relatively infrequent. The last-named writer mentions a case in which the nostril was thus encroached upon. It is a curious fact that cystic distension does not involve the lachrymal duct. Tumors of a fibrous and encephaloid nature, on the other hand, may cause overflowing of the tears from such involvement,[4] as well as paralysis of sensation in the affected part, as witnessed by Fergusson.[5] The origin of solid tumors involving the upper jaw is so obscurely localized that little of definite value can be written of it. That *necrosis* of so vascular a group of bones as those composing the upper jaw should occur in the degree seen in the following case is certainly very exceptional: In a male child, aged four years,

[1] Med. Times and Gazette, 681, 1862, part 2.

[2] Trans. Path. Soc. London, 1868; also Lancet, 1864, 153.

[3] System of Surgery, ii. 955, 962.

[4] Med. Times and Gazette, 1850, 231, part 2.

[1] Ibid., 1860, 35.

[2] Trans. Clinical Society of London, iii. 39.

[3] Ibid., v. 131.

[4] Dr. Mason Warren, Surgical Contributions; also Heath on Diseases of the Jaws, p. 256.

[5] Lancet, 1861.

a month after he had recovered from an attack of measles, an offensive discharge was announced from the right nostril. The right eye became prominent, and finally protruded conspicuously. The cornea sloughed, and the globe gave way. The right maxilla, the malar, and part of the sphenoid bone became necrosed. The child died at the end of eleven weeks of phlebitis of the ophthalmic vein, involving the base of the brain.

PALATAL BONE.

The palatal bone (figs. 5 and 6, Plate XX.) occupies the space which would otherwise exist between the superior maxilla and the pterygoid process. It is placed to the outer side of the nasal chamber and to the posterior part of the floor of the nose and roof of the mouth. It enters also into the composition of the floor of the orbit; and it assists in closing the posterior ethmoidal cells, and the inner border of the spheno-maxillary space and fissure. It is in the form of the letter L, with the angle produced downwards and the vertical member notched above. In addition to a palatal and vertical plate, it presents a pyramidal, an orbital, and a sphenoidal process.

The *palatal plate* corresponds to the plate of the same name of the superior maxilla. It is concave above to form part of the floor of the nose, and is nearly flat below, but smooth to enter into the construction of the roof of the mouth. Its anterior border is serrated for articulation with the palatal plate of the superior maxilla; the posterior is concave, to form the posterior border of the hard palate. Its inner border, when united with that of the opposite side, is produced posteriorly to form the *posterior nasal spine.* The junction of the horizontal and vertical portions of the bone is marked by an opening—the *posterior palatine canal*—and by a sharp ledge of bone extending inward from the base of the *pyramidal process*, to give attachment to the palatal aponeurosis.

The *vertical plate* extends from the floor of the nose to the level of the spheno-palatine notch. It is smooth externally, when it forms the internal boundary of the spheno-maxillary fossa. Internally it is marked by two *crests*—the upper for the middle turbinated, the lower for the inferior turbinated bone. It is grooved along its posterior border (forming the *posterior palatine groove*) for the posterior palatine artery and nerve.

Two processes arise from the termination of the vertical plate—the *sphenoidal* and the *orbital.* Of these, the *sphenoidal* appears to be the continuation of the vertical plate. It passes upward and backward as a thin wafer-like lamella, and, curving inward at its extremity, lies along the inner border of the base of the internal pterygoid plate to join the vomer. It thus may be said to enter into the construction of the roof of the nose. The *orbital process* is more robust, and is hollow. It forms the anterior boundary of the *spheno-palatine notch*, and enters into the floor of the orbit posteriorly and the spheno-maxillary fossa. It articulates with the superior maxilla, the sphenoid, and the ethmoid bones.

The *pyramidal process* or tuberosity is an elongated wedge arising at the union of the vertical with the palatal plates. It is directed outward and backward to be received into the pterygoid notch of the sphenoid bone. It is marked for articulation with the internal and external pterygoid plates. Between these is a smooth surface which enters into the pterygoid fossa.

The spheno-palatine notch, which lies between the orbital and sphenoidal processes, is converted into a foramen by the sphenoid bone, or by a plate of the palatal uniting the processes.

ARTICULATION.—The palatal bone articulates with the bone of the opposite side, and with the superior maxilla, the ethmoid, the sphenoid, the inferior turbinated bones, and the vomer.

DEVELOPMENT.—The palatal bone arises from a single centre of ossification which appears at the seventh or eighth week.

EXPLANATION OF PLATE XX.

Fig. 1. The ethmoid bone, seen from the lateral aspect. For "Christa galli" read "crista galli."

Fig. 2. The vomer, seen from the side.

Fig. 3. The superior maxilla, seen from in front and the side.

Fig. 4. The superior maxilla, seen from the median aspect.

Fig. 5. The palatal bone, seen from the lateral aspect.

Fig. 6. The palatal bone, seen from the median aspect.

PLATE XX

Fig 1

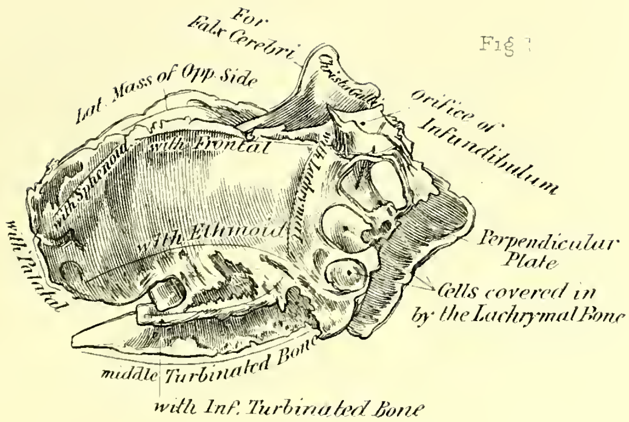


Fig 2

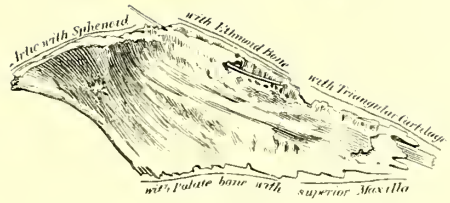


Fig. 3

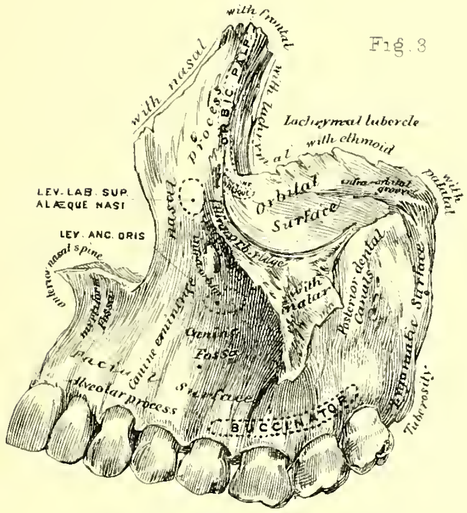


Fig. 4

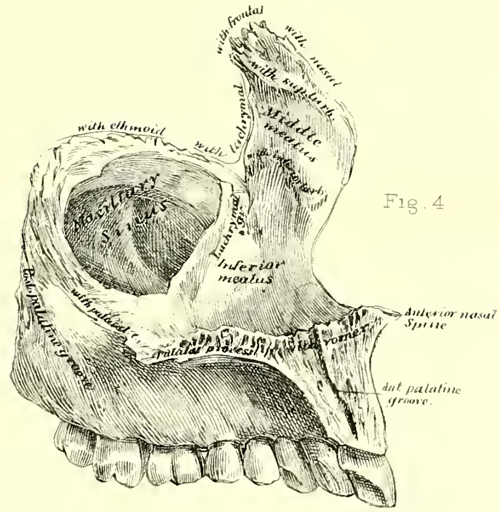


Fig 5

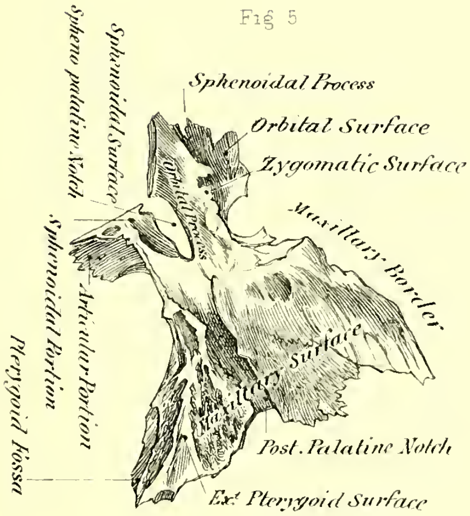
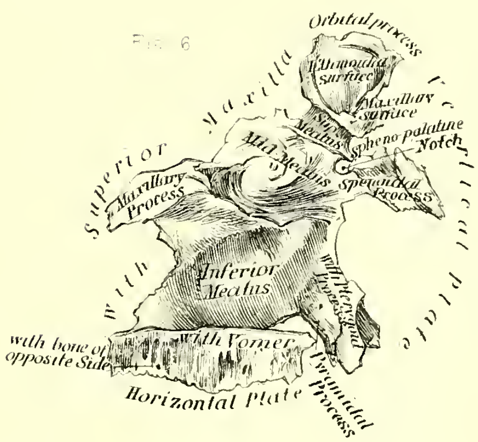


Fig 6



T. Sinclair & Son lith.

INFERIOR TURBINATED BONE.

The inferior turbinated bone is an elongated scroll of bone appended by its outer border to the inner wall of the maxillary sinus, and to the lower crest of the palatal bone. It consists of a body and three processes, the *maxillary*, the *lachrymal*, and the *ethmoidal*. Its inner border, at its anterior edge, is fixed to the inferior crest of the nasal process of the superior maxilla. The bone is curved from within outward, presenting a convexity toward the nasal chamber, grooved for vessels and nerves. The entire bone is of papery consistency, and is marked by minute depressions and elevations for the retention of the mucous membrane.

The *maxillary* process is a hook-like process of a semicircular shape. Hence the name, sometimes given to it, of the *auricular process*. It is applied to the inner wall of the maxillary sinus, and serves to maintain the bone in position. The *lachrymal* process passes upward and forward to articulate with the inner portion of the lachrymal bone. The *ethmoidal* process arises on the same plane a little further back, to effect a junction with the uncinate process of the ethmoid bone. The lachrymal and ethmoidal processes aid in defining the nasal wall of the maxillary sinus.

Articulation.—The inferior turbinated bone articulates with the superior maxilla, the palatal, the ethmoid, and the lachrymal bones.

Structure.—Dr. H. J. Bigelow[1] describes in the inferior turbinated bone a special arrangement of the cancelli, which he believes allies it with the erectile cavernous tissue as seen in the penis. The cancelli of the bone freely intercommunicate by irregular apertures, are lined with connective tissue, and are subdivided by bands of the same material. During life, blood is supposed to occupy these spaces, and to assist in maintaining the cushiony appearance of the mucous membrane over the turbinated bones, as well as to aid in closing the nasal chambers during attacks of congestion of the mucous surfaces. A similar appearance is seen in the middle turbinated bone.

Development.—It arises from a single centre at about the fifth month.

Remarks.—The inferior turbinated bone, receiving its supply through the vessels supplying the mucous membrane covering it, is liable to errors of nutrition dependent upon bloodvessel changes. It is thus apt to become hypertrophied from catarrhal inflammations, and is frequently lost by necrosis through the inflammatory infiltrations of syphilis. Among civilized races it is almost invariably asymmetrical, the larger bone always lying in the larger nasal chamber. In congenital cleft of the hard palate, the bone descends along its obtuse lower border and tends to occupy the cleft. The anterior narrowed extremity is a rudiment of the prolonged "alinasal" of quadrupeds, which, as the name implies, reaches to the snout, and lies directly behind the space to the outer side of the nostril. This ridge in the human skull may reach the anterior border of the anterior nasal aperture, but generally ends at a point a short distance within.

[1] Boston Medical and Surgical Journal, 1875.

MALAR BONE.

The malar bone is situated at the side of the face, where it joins the cranium. It forms part of the temporal fossa and the anterior portion of the outer border of the orbit. It is associated with the zygomatic process of the temporal bone to form the zygomatic arch. It presents for examination a maxillary, a zygomatic, and a frontal process.

The *maxillary* process is broad and irregular. It articulates with the malar process of the superior maxilla. The *frontal* process forms the inferior third of the outer edge of the orbit, and articulates with the external lateral process of the frontal bone. A thin plate is directed inward from the frontal process its entire length, to join the great wing of the sphenoid bone. It is called the *orbital plate*, and helps to separate the orbit from the temporal fossa. A small portion of the orbital process ordinarily remains free, and enters into the outer border of the spheno-maxillary fissure.

The *zygomatic* process is a broad thick plate passing backward from the side of the bone. Its upper margin is horizontal, and is continuous with the frontal process to form the fronto-jugal border. Its course is oblique, and continuous with the malar ridge of the superior maxilla, to form the maxillo-jugal border. The zygomatic process articulates with the corresponding process of the temporal bone through a serrate suture.

The malar bone presents a *subcutaneous* or *facial* surface. It is smooth, somewhat convex, and furnished with several minute foramina for the malar branches of the ophthalmic nerve. A *temporal* surface is formed by the temporal aspects of the zygomatic and frontal processes, and an *orbital* surface

by the orbital aspects of the frontal and malar processes.

Structure.—The malar bone is composed of stout lateral plates with intervening cancelli.

Articulation.—The malar bone articulates with the frontal, the superior maxilla, and with the zygomatic process of the temporal.

Development.—The malar bone arises from two centres of ossification. Hilgendorf[1] states that this takes place not infrequently. Sometimes these centres remain distinct, when the malar bone has been described as "double."

Remarks.—The facial surface between the orbital border and the position of the malar foramen is sometimes more convex than the rest of the bone. The temporal border of the frontal process quite commonly presents a process directed upward at the upper third in place of the swollen border, here commonly present.

THE LACHRYMAL BONE.

The lachrymal bone (figs. 1 and 3, Plate XXI.) is best seen upon the anterior portion of the inner wall of the orbit. It is a thin quadrilateral plate of bone lying in front of the os planum, back of the ascending process of the superior maxilla, below the internal lateral process of the frontal bone, and above the orbital plate of the superior maxilla. It is marked at its anterior third by a crest (*posterior lachrymal crest*) which aids in defining the *lachrymal groove*, the anterior wall of which is completed by a small crest on the ascending process of the superior maxilla—(*anterior lachrymal crest*). The groove is converted into a canal—the *ductus ad nasum*—by the aid of the nasal process of the superior maxilla and the lachrymal process of the inferior turbinated bone.

[1] Virchow's Archiv, 1879, 190.

Internally the lachrymal bone forms part of the outer wall of the nasal chamber. At this point the composition of the outer wall is complicated by the uncinate process of the ethmoid bone, which passes downward and backward to the inner side of the lachrymal bone; so that when the lachrymal bone is removed, this process occupies in part the opening; it thus serves to support the lachrymal.

The lower border of the lachrymal bone is thicker at the termination of the lachrymal crest than elsewhere, for the purpose of giving strength to the posterior wall of the *ductus ad nasum*. It articulates with the superior maxilla at the inner wall of the maxillary sinus, and with the anterior portion of the inferior turbinated bone.

Articulation.—The lachrymal bone articulates with the frontal, the os planum of the ethmoid, the superior maxilla, and the inferior turbinated bones.

Development.—The lachrymal bone arises from a single centre of ossification which appears about the eighth week.

Remarks.—The lachrymal bone may be much reduced in size or be absent. For anomalies, see Gruber,[1] and Luschka,[2] Gegenbauer,[3] and the writer.[4]

THE NASAL BONE.

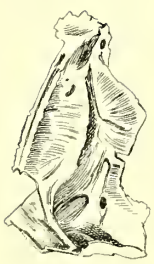
The nasal bones (figs. 2 and 3, Plate XXII.) are situated at the upper portion of the external nose. Each bone is longer than wide, and thicker above than below. It is smooth and gently convex from side to side on its facial surface, and concave upon the nasal, where it is grooved for the nasal nerve. The upper margin is serrated for articulation with the frontal bone, and at the nasal spine. The inferior margin is continuous

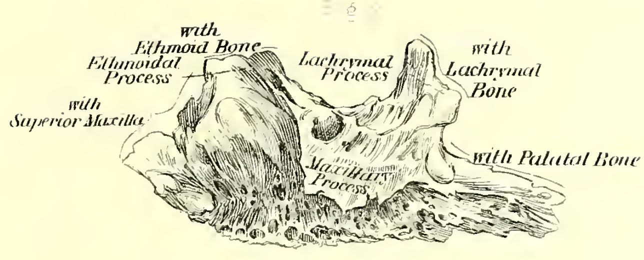
[1] Müller's Archiv für Anat. 1848, xiv. p. 413.
[2] Ibid., 1858, p. 304.
[3] Zeitsch. für Morphologie, 1881.
[4] Amer. Journ. Med. Sci., Jan. 1870.

EXPLANATION OF PLATE XXI.

Fig. 1. The lachrymal bone, seen from the median aspect.
Fig. 2. The inferior turbinated bone, seen from the lateral aspect.
Fig. 3. The lachrymal bone, seen from the lateral aspect.
Fig. 4. The malar bone, seen from the lateral aspect.
Fig. 5. The malar bone, seen from the median aspect.
Fig. 6. The inferior maxilla, seen from behind, and somewhat foreshortened.
Fig. 7. The inferior maxilla, seen from the side.

PLATE XXI





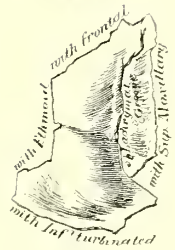
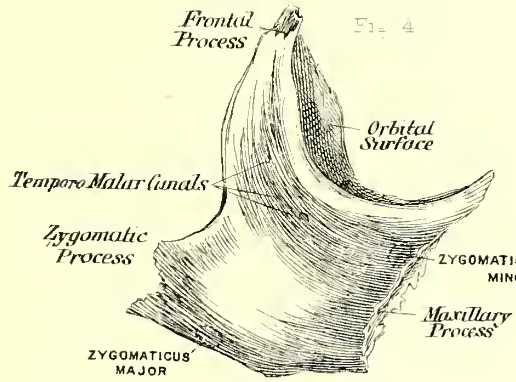


Fig 4



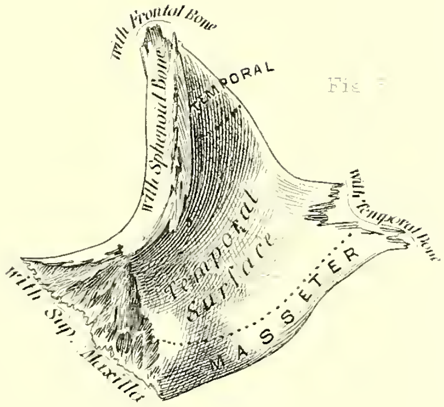


Fig 6

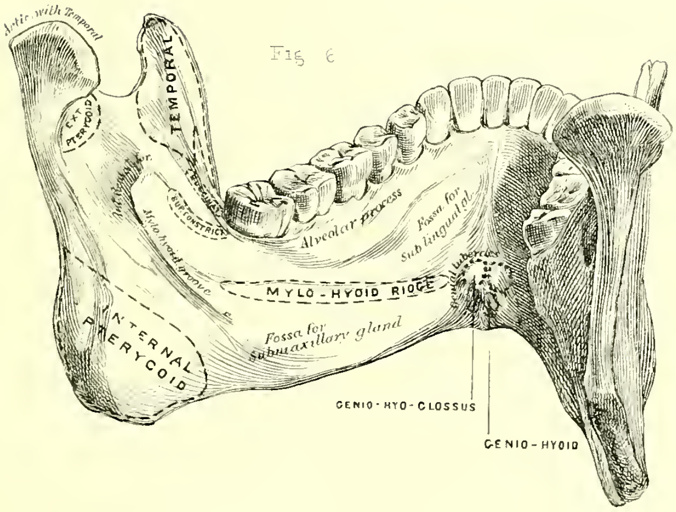
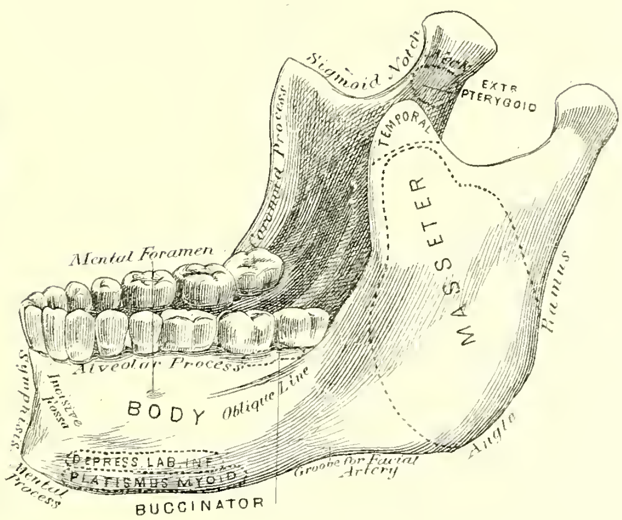


Fig 7



with the upper lateral cartilage of the nose, and is marked by a notch for the transmission of the nasal branch of the ophthalmic nerve. The median edge of the nasal surface forms a slight projection, which has received the name of the *nasal crest.*

STRUCTURE.—The nasal bone is of enormous relative thickness at its upper third: the lower portion is almost laminar in consistence.

ARTICULATION.—Each nasal bone is joined to its fellow of the opposite side, to the frontal bone, to the ascending process of the superior maxilla, and to the perpendicular plate of the ethmoid bone.

DEVELOPMENT.—The nasal bone arises from a single centre of ossification, which appears about the eighth week.

REMARKS.—The articulation at the upper portion of the bones gives the nasals great strength in resisting the shocks of blows. The weight of such blows is in great part received by the cranium through the medium of the nasals. Blows received upon the side of the nose may break or displace these bones with comparative ease.—That the nasal bones are in part sustained in position by the perpendicular plate of the ethmoid bone is made evident by the sinking of the osseous part of the external nose in loss of this plate by necrosis. The place of the nasal bones when these are congenitally absent, as is infrequently the case, is taken by the ascending process of the superior maxilla. It may be composed of a single bone lying below the conjoined ascending processes of the superior maxillæ.[1] In the cyclops variety of monster, which is characterized by an imperfect development of all the parts lying between the orbits, the rudiments of the nasal bones occupy a narrow projecting mass of skin-covered tissue entirely separated from the superior maxilla and the ethmoid bone, but in continuity through the normal attachment with the frontal bone.

THE INFERIOR MAXILLA.

The inferior maxilla or lower jaw (figs. 6 and 7, Plate XXI.) is the largest and most massive bone of the face. It forms the boundary of the under part of the anterior and the lateral region of the face, where its lower border can be defined under the skin. It consists of a horizontal arch, with its curves directed in front and its sides elevated at an angle behind. The bone is moved on the base of the skull at the temporal bone by powerful muscles.

The lower jaw is composed of two halves; after their union it is convenient to divide the bone into a body, or horizontal portion, and two ascending portions or rami.

The *body* of the bone laterally is marked above by the edge of the *alveolar process*, and below by a thickened, rounded border. In the median line at the point of union of the primitive halves is a linear ridge —the *symphysis.* The widened and projecting basal extremity of this line is called the *mental process.* At the side of the symphysis, on a line with the lateral incisor tooth, is the *incisor fossa*, from which the Levator Labii Inferioris arises. Below this point, and to its outer side, is a shallow depression for the Depressor Anguli Oris muscle. The line of insertion of the Platysma Myoides muscle lies below the latter, on the basal border. Opposite and below the interspace between the second molar and first bicuspid, and about midway between the basal border and the teeth, is seen the *anterior dental foramen*, which affords exit to the inferior dental nerve and artery. The basal border of the body near the ramus is grooved for the reception of the facial artery. Extending obliquely upward and backward to the anterior root of the coronoid process is the *external oblique* line.

The median side of the body is conspicuously divided by an oblique ridge, which extends from the base of the coronoid process downward and forward. This has received the name of the *mylo-hyoid ridge*, and serves for the origin of the Mylo-Hyoid muscle. Between this ridge and the molar teeth slips of the Buccinator and Superior Constrictor muscles are attached. At a point below the canine teeth, a smooth depression supports the anterior border of the sublingual salivary gland. Below the mylo-hyoid ridge, a small groove running nearly parallel therewith receives the mylo-hyoid nerve and artery. A well-marked oval depression near the basal border anteriorly is for the insertion of the Digastric muscle. At the lower part of the symphysis are found *the genial tubercles*, ordinarily composed of four processes—two on either side of the median line. The superior process is for the origin of the Genio-Hyo-Glossus, and the inferior for the Genio-Hyoid muscle.

The *ascending portion*, or *ramus*, is imperfectly defined from the body anteriorly. Posteriorly it pre-

[1] J. Van der Hœven, Jr., Zeitschr. für Wissenschaftliche Zoologie, xi., 1862, p. 138.

sents a robust, rounded border, which is separated from the basal portion of the body by the *angle*. The outer surface of the ramus is in great part roughened for the attachment of the Masseter muscle. It presents two conspicuous processes, the *coronoid* in front and the *condyloid* behind. Between them is a deep hollow, *the sigmoid notch*. The median aspect of the ramus is conspicuously marked by the *posterior dental foramen* for the entrance of the inferior dental nerve and artery. The anterior margin of this opening is produced into a thin plate of bone, pointing backward, which gives attachment to the deep fold of deep fascia known as the internal lateral ligament. The canal between the anterior and the posterior dental foramina is termed the *dental canal*. It passes beneath the alveolar process, and sends veins and bloodvessels to the teeth. At its beginning it lies near the inner surface of the bone, but towards the first molar tooth it holds a more central position in the jaw, and ends abruptly externally at the *mental foramen*.

The *coronoid process* is flat and pointed. It is directed slightly forward. It is thin at its upper portion, but thicker below. Its front edge is nearly straight, and presents at its base behind the third molar tooth a groove, within which is held a slip of the Temporal muscle, as well as the Buccinator muscle. Its posterior edge is thin, and continuous with the curve of the sigmoid notch. The lateral surface is devoted to the insertion of the Temporal and Masseter muscles, and the median to the Temporal alone.

The *condyloid process*, more massive than the coronoid, is a continuation of the posterior free margin of the ramus. It presents for examination a *neck* and an *articular* surface. The neck corresponds to that portion of the process directly below the articular. It is compressed from behind forward, and receives at its inner portion a shallow depression for the External Pterygoid muscle. The outer margin of the neck is marked by a minute rounded process, the *tubercle* for attachment of the external lateral ligament. The articular surface is convex from before backward, abruptly arched from within outward. It is often angulated at a point answering to the axis of the ramus. The articular surface is directed inward and somewhat backward. The production of the lines of inclination of the two surfaces would cause them to intersect each other at the anterior margin of the foramen magnum.

Remarks.—The inferior maxilla can be studied with great advantage for practical purposes from the following points of view: (*a*) As divided into a right and a left half; (*b*) as divided into the alveolar portion as one part, and the remainder of the bone as another; (*c*) as divided into a region of muscular impressions as one part, and the remaining non-muscular region as the other; (*d*) as divided by the mylo-hyoid ridge into *facial* relations (*i. e.* all the parts above the ridge and the entire outer surface of the bone) and *cervical* (*i. e.* all the parts below the ridge); (*e*) as compared with a long bone, especially with reference to the localization of tumors.

(*a*) *The lower jaw as divided into a right and a left half.*—The lower jaw, in common with other symmetrical parts of the skeleton, exhibits those curious connections between physiological and morbid action often witnessed in the long bones. This symmetrical distribution of disease is disturbed, however, by the union of the halves of the bone at the symphysis. It is probable that in lower mammals, such as the ruminants and the marsupials, in which the halves never unite, the symmetrical distribution of disease might be found better expressed than in man.

The following instances may be cited to show that disease *tends* to occupy the *sides* of the jaw rather than the median line, and that excesses of nutrition are apt to occur on either side of the symphysis in an equal degree. In confirmation of the latter statement, we may refer to those extraordinary developments of symmetrical hyperostosis recorded by Lebert[1] and Murchison;[2] and in proof of the former, to the clinical fact that growths of all kinds are vastly more common on the sides than on the median portion of the jaw. The only examples known to the writer, of a growth beginning on one side of the bone and passing across the median line, are the following: first, a tumor termed by Prof. Gross[3] hematoid which began on the left side just behind the cuspid tooth, and passed across the line of symphysis as far as the lateral incisor of the right; and second, the one described by Mutter,[4] which occupied the symphysis and about two-thirds of the left ramus of the bone. Hyrtl[5] alludes to a case of exostosis of the symphysis.

(*b*) *The lower jaw as divided into the alveolus as one part, and the remainder of the bone as another.*—This division is an important one to remember, for the following reasons: The alveolus is developed with the teeth and disappears with the teeth; it is an outgrowth from the jaw for a specific temporary purpose.

[1] Atlas, pl. xxxii. fig. 1.
[2] Trans. Path. Soc. London, xvii. 243, pl. 10, xii.
[3] System of Surgery, i. 485.
[4] Amer. ed. of Liston's Surgery, 299.
[5] Topograph. Anatomie, i. 324.

Jno. Hunter[1] declared that the "alveolar processes of both jaws should rather be considered as belonging to the teeth than as parts of the jaws."

It follows that all diseases of the alveolus are to be considered as dental in their significance. Thus epulis is peculiarly an alveolar disease. A tooth in any portion of the jaw other than that of the alveolus is as much out of place as though it were lodged in another bone. There is little doubt that the third permanent molar, when in the position so often assumed by it at the end of the alveolus, half within and half without the dental arch, with its roots, it may be, deflected within the compact and resisting tissue of the base of the coronoid process, acts as a foreign body; and as a splinter in the flesh provokes inflammation, so such a tooth is of necessity a fertile cause of diseased action about the angle of the jaw. Should a tooth be lodged beneath the alveolus, as in the encysted form, it either gives rise to chronic abscess or provokes those common tumors, the odontomes, which frequently are of such fearful import. Cystic disease about the angle of the jaw is so often excited by a misplaced third molar that the teeth should always be examined in attempting to diagnose this condition. In a case mentioned by Bordenave,[2] fetid matter from the collection about the wisdom-tooth escaped after removal of the second and third molars.

Dr. Mason Warren[3] describes a number of cases of cystic tumor of the angle of the jaw. In one of these the growth began by a swelling at the root of the third molar of the right side. By the end of several years it involved the whole right ascending ramus. It was of a globular shape, extended back under the lobe of the ear, and forward to encroach upon the cavity of the mouth. In another the growth extended backward into the parotid region, upward upon the face, and "inward to involve the right half of the palate, where it was covered by a highly irritable œdematous mucous membrane resembling that covering malignant growths in the same locality." There was a slight discharge of fluid through the remains of the socket of the last molar. This being enlarged, the cystic character of the growth was made clear. In a third instance, a growth of six years' duration, which attained the size of a hen's egg, began in the socket of the third molar.

It would be interesting to trace the connection between defects of the teeth-germs and congenital cystic tumor of the lower jaw, such as is described by Coate,[1] occurring on the right side of the lower jaw of an infant three months of age. Death ensued from exhaustion[2] following an operation for its removal.

That the body of the jaw is a growth distinct from the alveolus is shown in the study of cases of congenital defects of the bone. In the following rare manifestation of imperfect development characterized by permanent fixation of the two halves of the bone, we have, as the adult condition is attained, the jaw preserving the proportions of the infant as far as the body is concerned, while the teeth and alveolus are as well pronounced as in a normal jaw. Mr. Humphry[3] describes the case as follows:—

"The lower jaw is almost completely fixed, with the molar teeth clinched against the upper, so that there is no perceptible interval between them. The jaw is broad or natural at the angles, and the angular parts have descended nearly to their proper level; but the arch formed between the two angles is extremely small. Indeed, the body and the mental portions of jaw run forward scarcely at all, and do little more than pass from one angle to the other. The chin is in a plane two inches behind the alveolar edge of the upper jaw, instead of being a little in front of it. There has been, therefore, a failure, amounting to at least two inches, in the growth of the body of the jaw in length; and it is also less deep than natural. The failure, however, has not been shared in quite an equal degree by the alveolar portion. This forms a segment of a larger circle, taking a wider sweep, and, consequently, overhanging the lower part of the body of the jaw. By this means greater room is given for the teeth, which are as numerous and *as large as natural;* and they are disposed in a slanting fan-like manner, so as to bring the crowns of the molars and hinder bicuspids into contact with those of the upper jaw."

(*c*) *The lower jaw divided into muscular impressions as one part, and the rest of the bone as the remaining part.*—Both sides of each ascending ramus may be said to be large muscular impressions—the lateral for the Masseter, the median (less completely covered) for the Pterygoid muscles, while the tendon of the Temporal muscle embraces the coronoid process. The arch of the bone can be called, for the most part, a non-muscular area; for with the exception of the in-

[1] Palmer's Hunter, i. 4.

[2] Surgical Essays, Sydenham Series.

[3] Surgical Observations, with Cases and Operations. Boston, 1867, 72.

[1] Sydenham Retrospect, 1861.

[2] For a cystic tumor not apparently connected with the teeth, yet strictly alveolar, see R. Adams, Med. Times and Gazette, 1857, 484.

[3] Med.-Chir. Rev., 2d series, xxvii. 1862, 288.

sertion of the Digastric muscle at the small digastric fossa, and of the Genio-Hyoid group at the genial spine, the muscles here (viz., the Mylo-Hyoid muscle *within*, at the ridge of the same name, and the Depressor Anguli Oris and the Platysma Myoides muscles at the mental process *without*) constitute an unimportant element.

It is particularly with the ascending ramus that the muscular impressions are found to be of value in the study of lesions and diseased action. In the first place, the Masseters act as external cushions protecting the jaw from direct violence, while the Pterygoids act as internal cushions to prevent bilateral dislocation. In the second, the direct influence exerted on the shape of the angle by the Internal Pterygoid is often very marked. A condition known as incurvation of the angle is frequently seen in well-marked specimens of the lower jaw. It was at one time thought that this peculiarity stamped the individual as an example of a low type of man. It is a curious fact (only noteworthy from its liability to deceive in attempting such generalizations) that the same incurvation of the angle is a constant character in the jaw of the marsupials—a low group of the mammalia.

Another feature of importance is the fixity of the ascending ramus by the contraction of the masticatory muscles. Other things being equal, the position of elevation or depression of the lower jaw will make the difference between a dislocation and a fracture. If the jaw at the time of the injury be elevated, the bone is apt to be broken by the direct violence applied to it; if, however, it be depressed, it is more apt to be dislocated. The ensuing case is of value in illustration of this principle, since the lines of fracture were doubtless determined by the fixed position of the jaw.[1]

A young man whilst plowing was thrown down by his bullocks running away, and the coulter, catching his throat, tore away the entire horizontal portion and more than half of the right ramus of the lower jaw. "A lacerated wound extended from the right mastoid process across the throat nearly to the left angle of the jaw; this at its posterior origin had entirely divided the whole breadth of the Sterno-Cleido-Mastoid muscle; from the right angle of the jaw to near the chin it divided the floor of the mouth. It was also met by an oblique laceration from the left commissure of the lips, which had quite torn through and divided the cheek. The inferior maxilla was fractured on both sides, on the right more than half-way up the ramus. The bone thus broken and torn out of the face was very much denuded of soft parts, and at each fractured extremity was, to some extent, laid bare of periosteum." Six weeks after the injury, the right side of the face was paralyzed; the eye could not be closed, nor the mouth entirely.—The specimen embraced the entire horizontal portion of the jaw, and more than half of the ramus of the right side. The ramus had been fractured obliquely backward and downward from the root of the coronoid process to the middle of the posterior edge. On the left side the fracture extended obliquely across the angle, from behind the socket of the second molar tooth to just in front of the posterior part of the angle of the jaw.

According to Hamilton,[1] fracture of the condyloid process almost always occurs just below the insertion of the External Pterygoid muscle.

(*d*) *The lower jaw as divided by the mylo-hyoid ridge into two groups of relationships—one* above (*facial*), *the other* below (*cervical*).—The Mylo-Hyoid muscle is the floor of the mouth, and abruptly separates the inner aspect of the curve of the body from the rest of the bone. The relations of this region are entirely with the neck.

(*e*) *The lower jaw as compared to a long bone.*—The lower jaw resembles a long bone in having compact bone *without* and cancelli *within*; in having a well-defined canal (somewhat comparable to a nutritive foramen) entering it obliquely; and in having an active periosteum. It conspicuously differs from a long bone in the absence of an epiphysis. The bone is thus deprived of an epiphysial period, which is so prolific in morbid processes. The *ends* of the lower jaw (*i. e.* the articular surfaces) are peculiarly exempt from disease, the very opposite to what is seen in long bones. The only known instance of restricted disease at these points is caries, with subsequent hyperostosis. Mr. Tatum[2] briefly describes a unique case of fluid in the temporo-maxillary articulation escaping into the external meatus following a lesion of the latter.—The lower jaw also differs from a long bone in retaining contact with mucous membrane. When in fractures of the lower jaw the gum is deeply lacerated, the fracture at once becomes compound. The ease with which this can occur, and the consequent frequency of this occurrence, place maxillary fractures in a group entirely distinct from that of other bones. It has been asserted (and on good grounds) that the contact of the air and saliva between the ends of the broken bone

[1] J. Thomson, Edin. Med. Journal, 1861, vii. 587.

[1] Treatise on Fractures and Dislocations.

[2] Lancet, 1860, ii. 536.

tends to provoke ostitis and suppuration, with their sequelæ, constitutional disturbance, and increased risk of pyæmia.—The methods of securing vascular and nervous supply are widely remote from one another. In the lower jaw the bloodvessels and nerves enter by a canal which is primarily a groove in the embryonic bone, and which in necrosis is probably included in great part within the thickened osteogenetic periosteum. The dental nerve and vessel are designed, in a word, for a special object within the jaw, as well as to give blood and nerve-supply to the bone: thus holding the same relation to the jaw that the hepatic artery and nerve hold to the liver. The lower jaw is, independently of the teeth, not a very vascular bone. It succumbs readily to attacks of necrosis, as much from this cause as from its peculiarly exposed situation.

The ostitis preceding necrosis in the lower jaw is almost always more marked than in a long bone, and the pain is greater. The latter symptom often resembles that of intermittent toothache, thus complicating the diagnosis. The swelling of the cheek and gums, the difficulty in mastication, and the dysphagia, as well as the increased activity of the mucous and salivary glands, are distinctive symptoms. The presence of a sequestrum may, according to Butcher,[1] induce vomiting and difficulty in speech and swallowing. Thus, we have as a result of a branch of a cranial nerve being held in connection with the products of inflammation—if it be not itself inflamed—an excitation of a larger circle of sympathies than can arise from analogous conditions within a long bone.

T. Holmes[2] mentions the occurrence of fatal hemorrhage from the lingual artery excited by a maxillary sequestrum.

Necrosis of the lower jaw, as a sequela of measles, scarlet fever, smallpox, and typhoid fever—diseases whose lesions are for the most part splanchnic—cannot be compared to anything seen in the long bones. The same remark is true of phosphor-necrosis. It will be remembered that this disease always invades the jaw through a carious tooth or open socket—proving not only that the direct contact of the poisonous agent with the cancelli is requisite, but that such contact is *possible* only in the jaws; for no such relationship of cancelli to an open surface is ever seen in a long bone. A transverse section of the compact structure of the jaw may be compared to a vase. The base of the vase is firm and thick; the sides become thin as they approach the brim, while the upper surface is open. If a tooth is removed, the cancelli are at once exposed. Applying this explanation to the shape of sequestra, it will be seen that a sequestrum of the lower jaw or an exfoliation from the ends of a broken bone must be more or less U-shaped, as the same specimens from a long bone are more or less cylindrical. This rule does not apply to syphilitic necrosis.

[1] Essays and Reports on Operative and Conservative Surgery. R. G. Butcher. Dublin, 1865, 307.

[2] Holmes's System of Surgery, iii. 645.

According to Stanley,[1] nine months are required to restore a lower jaw through the activity of its periosteum after the bone has been destroyed by necrosis.

The comparison between the lower jaw and a long bone is interesting in studying the subject of removal. The wide range of sympathies seen in ostitis and necrosis of the lower jaw is to be expected in excision of that bone. In the event of amputation of a limb proving fatal, we commonly find pyæmia or secondary hemorrhage playing a ghastly rôle. While these prodromes to fatal disaster are unfortunately not wanting in the other operation, we more frequently find erysipelas and shock the exciting causes of sudden death. In summing up the experience gained in seven amputations, J. W. Casack[2] says: "Fatal cases of diffused inflammation succeeding to operations in the vicinity of the base of the lower jaw are by no means infrequent." In one of his cases, the erysipelatous inflammation involved the parts about the larynx, death ensuing on the ninth day after the operation. Mr. Symes[3] narrates a case of excision which proved inexplicably fatal on the second day.

(*f*) *The lower jaw as determining the localization of tumors.*—From an anatomical standard, this subject, of great intricacy in other relations, resolves itself into a few simple propositions:—

1st. When a tumor originates within or beneath the gum, and involves the cancelli secondarily, it indubitably belongs to the alveolar group of morbid growths. The different varieties of epulis are thus anatomically restricted.

2d. Fibrous tumors, according to Nélaton, may either arise within the body of the bone, when by their growth they will encompass the bone, or, having their origin beneath the periosteum, they may protrude toward the affected side. The same writer affirms that they tend to develop toward the cutaneous rather than toward the mucous (oral) aspect of the bone. Fergusson[4] describes a fibrous tumor which lay inclosed

[1] Trans. Path. Soc. London, iii. 169.

[2] Dub. Hosp. Rep., iv. 1827, 1.

[3] Surg. Contributions, 21.

[4] Med. Times and Gazette, 1865, 141.

within the expanded and attenuated tables of the jaw. The central encapsuling fibrous tumor may involve the dental nerve, as described by T. Bryant[1] in a tumor which was removed from the left side of the body of the lower jaw of a boy nine years of age. It was of two years' duration, and followed a blow received six months before. The nerve was found running through the centre of the growth. It would appear that encephaloid disease may originate in the dental canal, judging by the case reported by Nunneley,[2] in which the disease was ushered in by numbness of the left side of the lower lip. This was followed by varying pains in the canine and in two adjoining teeth of the same side. The last molar was extracted with a view of relieving the toothache. The case, the nature of which now became evident, progressed rapidly to a fatal termination.

3d. The lower jaw being in the line of growth of epithelial tumors of the lower lip, secondary cancers from that source are not infrequently seen. In a case coming under the notice of the writer, the disease had progressed from the lip along the line of the right side of the horizontal portion, opening the oral cavity from the side and destroying the alveoli. The tongue, thus deprived of lateral support, lolled outward, and the saliva dropped continually upon the neck. Fortunately, these extreme degrees of destructiveness are rare, but the probability of secondary involvements of the lower jaw from neglected epithelial cancer should never be overlooked.

THE SKULL.

The skull (figs. 1 and 2, Plate XXII.) is composed of the *cranium* and the *face*. It is convenient to include between these divisions a third — the *cranio-facial* or *intermediate portion.*

The term cranium is often applied to the entire framework of the head, either with or without the lower jaw. In a more exact sense, the *cranium* is the *brain-case.* The *face* is a region made up of bones that are in contact with mucous membrane—the malar bone alone excepted—and affords protection to the visual, olfactory, and dental organs, besides defining the nasal and oral cavities.

The brain-case and the face are distinct in their development. The brain-case possesses a central tract—the cranio-basic axis—which corresponds in general direction to that of the chorda dorsalis. It consists of the basilar process of the occipital bone and the body of the sphenoid bone. The vomer and the perpendicular plate of the ethmoid bone represent parts of the cranio-basic axis projected into the face. The chorda dorsalis does not advance further than the posterior clinoid processes. The lateral portions of the occipital bone and the wings of the sphenoid bone arise in pairs from the axis. The nasal bones and incisorial portion of the superior maxilla descend from the primordial frontal process of the frontal bone. The remaining portion of each superior maxilla, together with the lower jaw, arises from the side of the base of the skull. Each of the facial bones not mentioned in the above category appears in its appropriate place as a separate ossicle having slight morphological significance.

THE CRANIUM.

The cranium is divided into the *vault* and the *base.*

THE CRANIAL VAULT.—The cranial vault (figs. 1 and 2, Plate XXII.) is limited *anteriorly* by the supra-orbital arches and the fronto-nasal suture; *laterally* by the zygomatic arch, the orifice of the external auditory meatus, and a line running thence along the superior semicircular line to the occiput, which terminates the vault *posteriorly.* The *skullcap* or *calvarium* is defined by a horizontal section of the vault about one inch above the external angular process of the frontal bone.

The cranial vault is an ovoidal figure, broader behind than in front, and abruptly narrowed behind the external angular processes. It is slightly compressed at the sides at the temporal fossæ, and more or less expanded behind. The anterior portion of the vault is termed the *frontal region* or *sinciput*, the posterior the *occiput*, and the top the *vertex.* The *side* is made up in great part of the temporal fossa.

The *forehead* (sinciput) is defined inferiorly by the supra-orbital margins and the line of the fronto-nasal suture; superiorly, by a transverse imaginary line half-way between the frontal eminences and the coronal suture; and, laterally, by the temporal ridges. Directly between the orbits, and extending thence downward one-half the height of the inner margin of the orbit and upward about an inch upon the supra-orbital curve, is a smooth, rounded space, with a faintly convex surface, called the *nasal eminence* (glabella). This eminence corresponds to the anterior wall of the frontal sinus, and varies in size according

[1] Trans. Path. Soc. London, 1858, 352.
[2] Trans. Path. Soc. London, xiii. 1862, 215.

to the degree of development of the sinus. At the inner third of the supra-orbital arch of each orbit is seen the *supra-orbital notch*, which transmits the nerve of the same name. The notch is often converted into a foramen. A little further out from the border is the foramen for the supra-trochlear nerve.

The frontal and superciliary eminences lie upon the line between the eyebrows and the scalp, which limits from above downward the "forehead" of common language. Ordinarily the "forehead" is occupied by the fleshy fibres of the anterior portion of the Occipital Frontalis muscle. Occasionally a median depression marks the locality of the *inter-frontal suture*, formerly present at this place.

The back of the vault or *occiput* answers to the ascending portion of the occipital bone above the protuberance. It includes the lambdoidal suture, and is covered with the hairy scalp.

The *top* or *vertex* (crown) extends from an imaginary line half way between the coronal suture and the frontal eminence to the angle of the occipital bone. It embraces the parietal bones between the parietal eminences, and is marked in the median line by the *sagittal suture* (inter-parietal). It is everywhere smooth and convex, and covered by the hairy scalp.

The *side* of the skull is defined above by a line extending from the external lateral process of the frontal bone along the temporal ridge, and thence to the occipital protuberance, and below by a line answering to the lower limitation of the vault. It is made up in great part of the *temporal fossa*, so named from its occupancy in the undissected subject by the Temporal muscle. The fossa is formed by the temporal, parietal, frontal, sphenoid, and malar bones. It is deeply concave behind the orbito-temporal septum, at a point answering to the greater wing of the sphenoid bone and the pterion, and more shallow and convex posteriorly, where it is gradually lost upon the masto-occipital surface.

The anterior portion of the temporal fossa is deeper in the negro than in the Caucasian type. The temporal ridge is often represented in the adult skull by several faint lines, which answer to the lines of growth of the skull. The ridge in narrow skulls approaches its fellow of the opposite side to a greater degree than it does in broad skulls.[1] In congenital arrest of brain-growth and in low types of skulls, as in the Australian and in some paleo-lithic forms, this approach is decided, and resembles that constantly met with in the lower animals.

[1] Lucæ, J. C. G., Architectur des Menschenschädels, 1857, pl. xv.

Measurements.—Draw a line from the fronto-nasal suture, and continue it over the top of the skull to the occipital protuberance. Cross this line by a second extending transversely from the upper border of the external meatus. Hyrtl finds that a line drawn from the middle of the sagittal suture to the anterior portion of the foramen magnum is about two to three inches less than the transverse line. It will be seen that the skull taken as a whole is most capacious at the junction of its posterior with its middle third. Measurements taken as suggested by curved lines are more satisfactory than those taken by means of callipers. A fixed relation should be found between the curves made by these lines in comparing measurements.

To aid in securing exact measurements of crania the following terms of Broca, as defined by Flower,[1] will be found useful:—

Alveolar point. The centre of the anterior margin of the upper alveolar arch.

Subnasal point or *Spinal point.* The middle of the inferior border of the anterior nasal aperture, at the base of the nasal spine.

Naison or *Nasal point.* The middle of the naso-frontal suture at the base of the nose.

Ophyron. A point situated immediately above the nasal eminence, or, more exactly, the centre of the supra-orbital line, which, drawn across the narrowest part of the forehead, separates the face from the cranium.

Bregma. The point of junction of the coronal and sagittal sutures.

Opisthon. The middle of the posterior margin of the foramen magnum.

Basion. The middle of the anterior margin of the foramen magnum.

Pterion. The point of junction of the frontal, sphenoid, parietal, and temporal bones on the anterior parts of the temporal fossa.

Stephanion. The point where the temporal ridge crosses the coronal suture.

Asterion. The point behind the mastoid process where the parietal, occipital, and temporal bones meet.

The vault of the skull differs greatly in degree of thickness. It may be exceedingly thin and brittle, or excessively thick.

The skull is thickest at the occiput, where its average measurement is three-quarters of an inch. It is thinnest at the temple and the roof of the orbit.

[1] Osteological Catalogue of the College of Physicians and Surgeons, London, Part I., 1879.

In estimating the amount of force required to fracture the bones, as well as that required to conduct the operation of trepanning, the possibility of the occurrence of a cranial vault with thin brittle walls should never be forgotten. The vault is always thinner at the point of contact with the Pacchionian bodies upon its under surface than it is elsewhere.

While a general relation between the form and volume of the brain and the brain-case is conceded to exist no exact correlation can be detected between the two. The large side of the cranium may correspond to the smaller cerebral hemisphere. The inner and outer layers of the skull may separate widely; and the outer may not be concentric or parallel to the inner. The frontal sinus is of varying size, and bears no relation to the size of the related cerebral lobes; nor do the details of the interior of the brain-case correspond to the inequalities of the cerebral convolutions.

The Sutures of the Cranial Vault.—The sutures of the cranial vault are the *interparietal* or *sagittal*, the *fronto-parietal* or *coronal*, and the *occipito-parietal* or *lambdoidal.*

At the *sides* of the vault the lower ends of the coronal and lambdoidal sutures are seen. In addition the fronto-malar unites the external angular process of the frontal bone with the frontal process of the malar bone; and in the temporal fossa sutures are formed by the union of the antero-inferior angle of the parietal bone with the tip of the greater wing of the sphenoid bone (*parieto-sphenoid*), with the parietal bone and the squamous portion of the temporal bone (*parieto-squamosal*), and with the postero-inferior angle of the parietal bone and the mastoid portion of the temporal bone (*parieto-mastoid*).—The anterior portion of the temporal fossa is marked by the nearly vertical *fronto-sphenoidal* and *sphenoido-squamosal* sutures.

The *occiput* exhibits the greater portion of the occipito-parietal suture and a portion of the vertical limb of the *masto-occipital.*

The *forehead* retains sutures with the facial bones where the frontal bone articulates with the frontal, sphenoid, ethmoid, lachrymal, superior maxillary, and nasal bones. These several sutures can be readily named by combining the names of the two bones entering into them. The unscientific name "*transverse suture*" is sometimes given to all the sutures above named. The suture in the median line of the frontal bone of the skull of the infant forms the *frontal suture.* It rarely persists in the adult. The sutures of the vertex are variously dentated, while those of the base are slightly sinuate or straight. The degree of indentation is subject to great variety, yet presents a regular plan of distribution which may be thus epitomized: the parietal bones, where they first unite with one another, namely, about the middle third of the interparietal margin, exhibit dentations of a character different from those at the anterior and posterior thirds. At the anterior third they are not pronounced, and may be absent; at the posterior they are narrow and long.—The parietal bones unite with the frontal at the middle third of each half of the frontal bone, the upper and lower third presenting less coarse dentations. The dentations often end abruptly at the intersection of the coronal suture with the upper margin of the temporal fossa, the coronal suture below this point being, as a rule, sinuate or straight. The lambdoidal suture is coarsely dentate throughout. From the above it appears that the sutures are dentate in a degree proportionate to the places at which contact first occurred. In the region of the fontanelles (see succeeding section) the sutures are nearly straight or harmonic.—In the negro the dentations are less prominently developed than in other races.

The Fontanelles and Disappearance of the Sutures.—The fontanelles are the spaces between the incomplete angles of the cranial bones. They are occupied by membrane, which gradually becomes ossified as development advances. The fontanelles are four in number, and are formed in part by the four angles of each parietal bone. They are named the *median* and the *lateral* fontanelles. The *anterior median fontanelle*, or great fontanelle, lies between the antero-superior portions of the parietal bones and the halves of the frontal. It is of a lozenge or spear-head shape, and continues by its angles with the sagittal, coronal, and frontal sutural interspaces. It is the largest of the fontanelles. It disappears from the tenth to the fifteenth month, holding in this respect a close relation with the rapidity of the development of the entire osseous system. In a quickly closing fontanelle the teeth appear soon, and the child walks early. In cases of retarded development, on the other hand, the fontanelle remains open and larger, and indeed, though this is rare, it may persist through life.—The *posterior median fontanelle* is placed between the postero-superior angles of the parietal bones and the occipital angle. It is triangular in shape, and continuous with the lambdoidal and interparietal (sagittal) sutural interspaces. It is closed at birth or a few months after.—The *lateral fontanelles* lie at the antero-inferior

and at the postero-inferior angles of each of the parietal bones and the adjacent parts. They are small, unimportant, and disappear at birth. The hinder angle of the posterior lateral fontanelle is continuous with the interval between the divisions of the ascending portion of the occipital bone. Hyrtl records four instances in the adult skull of the persistence of a fissure answering in position to this angle. It is a striking fact that hernia of the brain never occurs through the fontanelles.

At birth the sutures of the vertex are so imperfectly formed that the bones can be made to slide slightly upon one another under moderate compression without injury to themselves or to the brain beneath. Such compression is inevitable during the delivery of the child, and is liable to take place to a greater or less extent during infancy. Post-mortem changes go on more rapidly in the brain when the fontanelles remain open than after they are closed. This fact is of medico-legal significance.[1] The protection secured to the sutures of the side of the skull appears to favor their early obliteration. Thus the coronal suture may be no longer traceable in the temporal fossa while yet distinct on the vertex. The sutures holding the temporal bone in position seem to disappear later than other cranial sutures, probably owing to the less pronounced organic union of this bone with the remaining cranial bones.

The time at which the sutures disappear varies with the different bones, with race peculiarities, and, as has been noted, with the rate of activities of the general ossific development. This rate is less active in cold than in warm climates. Other things remaining the same, the sutures disappear in the order of the completion of the development of adjacent parts. At fifty-five or sixty years, the sutures have become entirely obliterated. The sutures may separate under the distending force engendered by brain decomposition.[2]

Universal union of the cranial sutures constitutes *synostosis*. Should one or more of the sutures close while the skull is yet growing, deformation occurs. This is probably a frequent cause of variation in the shape of the vertex. The sagittal suture prematurely disappearing restrains the lateral expansion of the vertex, while forcing out the forehead and occiput. A skull thus deformed is known as the *scaphoid* or *boat-like* skull.

Premature sutural union is not of necessity evidence of the arrest of the development of the brain.

[1] Casper, i. 46, Syd. Soc. edition.

[2] Casper, l. c. i. 40.

Disappearance of the suture may result from excessive precocity of the osseous system, without any corelation existing between the growth of the brain and that of the skull. A distinct class of symptoms arises when the brain continues its growth within an unyielding brain-case, which is recognized by clinical writers.

The effect of a prematurely united suture upon the general nutrition of the bones adjacent to it is decided. The edges entering into the sutural line are thickened, while the substance of the bone a little distance from the line is thinned, and, in rare instances, is even perforated (see Parietal and Occipital Bones).

The deformities of hydrocephalus are largely determined by the condition of the sutures at the time of the occurrence of the disease. Fixation at the line of the sagittal suture causes bulging at the forehead and the occiput. Fixation at both the lambdoidal and the sagittal sutures causes vertical bulging at the line of the coronal suture, and enormous increase of the ascending portion of the frontal bone. Should the intra-cranial pressure announce itself prior to the closure of any of the sutures of the vertex, the several bones composing it become widely separated, and the fontanelles enormously increased in size.[1]

The bones of the vertex, arising as they do from membranous expansions, present a group of variations distinct from those that arise from cartilage. Prof. Turner[2] endeavors to account for this by stating that the areas of the different bones are less precisely defined, and that the process of ossification is more liable to disturbance in the former than in the latter. The modifications in arrangement are especially apt to occur along the lines of apposition of adjacent osseous areas, as, for example, along the sutural lines, or along the margins of the subdivisions of a bone proceeding from distinct centres.

The Wormian Bones (ossa triquetra). — The Wormian bones are variable in shape, number, and position. They are seen, in order of frequency, between the occipital and the parietal bones, at the junction of bones at the anterior third of the temporal fossa (*pterion*), and at the regions of the fontanelles. They are rare in the face, and are here almost confined to the roof and median surfaces of the orbit. They are unknown in the cranio-basic axis. It will thus be seen that the Wormian bones answer to the position of the membranous expansions, as opposed to

[1] Rudolphi, Berlin. Abhandl. (Phys.), 1824, 121, figs.; also J. von d. Hoeven, Acad. Cæs. Leap. Nova Acta, xxix. 1862, figs.

[2] Edinburgh Royal Soc. Proc., v., 1866, 444.

the cartilaginous, and to the concave walls of extending spaces. They are, indeed, detached centres of ossification in the marginal area of growing membrane bones, which they aid in occupying intervening spaces among the bones themselves. They of necessity follow the rule of symmetry.

Portal alludes to the fact that the Wormian bones have been depressed in injuries of the skull, and have resembled fragments of bone pressing against the meninges. Sauceratte[1] reports a striking instance of error in diagnosis dependent upon mistaking the edge of a Wormian bone for a line of fracture. A trephine was about to be applied to the presumedly fractured point when the error was detected.

The Cranial Base.—The base of the skull presents two surfaces for examination—an interior and an exterior surface.

The *interior* base of the skull (fig. 1, Plate XXIII.; fig. 3, Plate XXIV.) is divided into three sections, which comprise the *anterior*, *middle*, and *posterior* cerebral fossæ.

The *anterior* cerebral fossa is composed of the horizontal plate of the ethmoid bone, and the body of the sphenoid bone in advance of the olivary body. At the sides lie the orbital plates of the frontal and the lesser wings of the sphenoid bone. The floor is thin and compact, slightly convex over the orbits, and concave for the olfactory grooves. It is pierced by the foramen cæcum, by the openings for the olfactory nerves, and by the optic foramen. It contains the anterior cerebral lobes and arteries, the olfactory tracts and bulbs, and the optic chiasm.

The *middle* cerebral fossa presents in the cranial axis the pituitary fossa and the clinoid plate; laterally, the great wing of the sphenoid and the squamous bone compose it. It is defined anteriorly by the lesser wing, and behind by the anterior aspect of the petrous bone. It presents everywhere a concave surface; is irregularly marked with a number of digitate depressions; is thinned at the eminence corresponding to the glenoid fossa, and at a point a little in advance of the foramen ovale; is pierced by the anterior lacerated foramen, the oval foramen, the spinous foramen, the hiatus Fallopii, and the termination of the carotid canal; and accommodates the middle cerebral lobe, the Gasserian ganglion, and the encranial divisions of the primal branches of the fifth pair of nerves.

The *posterior* cerebral fossa includes the following parts: At the middle line is seen the cranio-basic axis as far as and inclusive of the posterior clinoid processes. Behind this axis lies the foramen magnum, and beyond this in turn lie the internal occipital protuberance and the line extending thence to the foramen magnum. At the side, the posterior aspect of the petrous portion of the temporal bone and the related mastoid portion are seen. The posterior cerebral fossa is marked by the jugular eminence, and by the lateral groove for the sinus of the same name. The skull is very thick at parts answering to the base of the lateral sinus on the occipital bone. The posterior cerebral fossa is pierced by the foramen magnum, by the hypoglossal canal, by the posterior lacerated foramen, by the internal auditory meatus, and by the mastoid foramen. It contains the medulla oblongata, the cerebellum, the basilar artery, and encranial portions of the cranial nerves from the third to the twelfth. That portion of the posterior cerebral fossa lying below the groove for the lateral sinus on the occipital bone may be called the *cerebellar fossa*.

The *interior* base of the skull conforms more nearly to the shape of the base of the brain than does the vault to its related brain surface. Injuries to the head may cause direct concussion and laceration from the violent contact of the brain against the interior base. According to Hilton,[1] when the blow is received at the posterior part of the skull, the whole mass of the brain being driven forwards from the momentum given to it by the blow upon the bones of the skull, the under surface of the anterior part of the brain rubs over the depressed and elevated surfaces which

[1] Mélange de Chirurgie, ii. 262.

[1] Lectures on Rest and Pain, 25.

EXPLANATION OF PLATE XXII.

Fig. 1. The skull, seen from in front.
Fig. 2. The nasal bone, seen from in front.
Fig. 3. The nasal bone, seen from behind
Fig. 4. The skull, seen from the side.

PLATE XXII

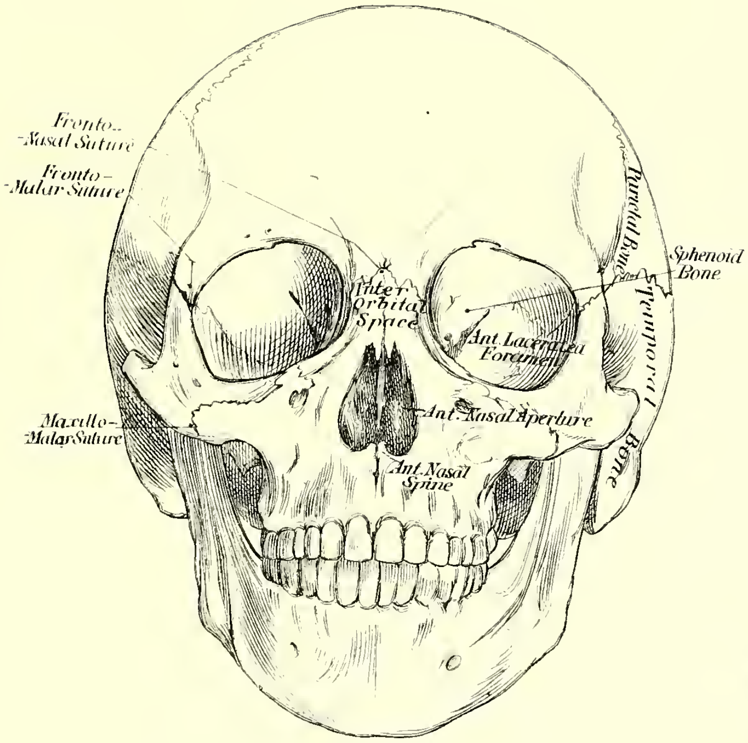


Fig 1

Fig 2

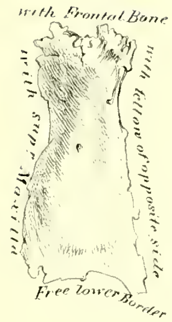


Fig 3

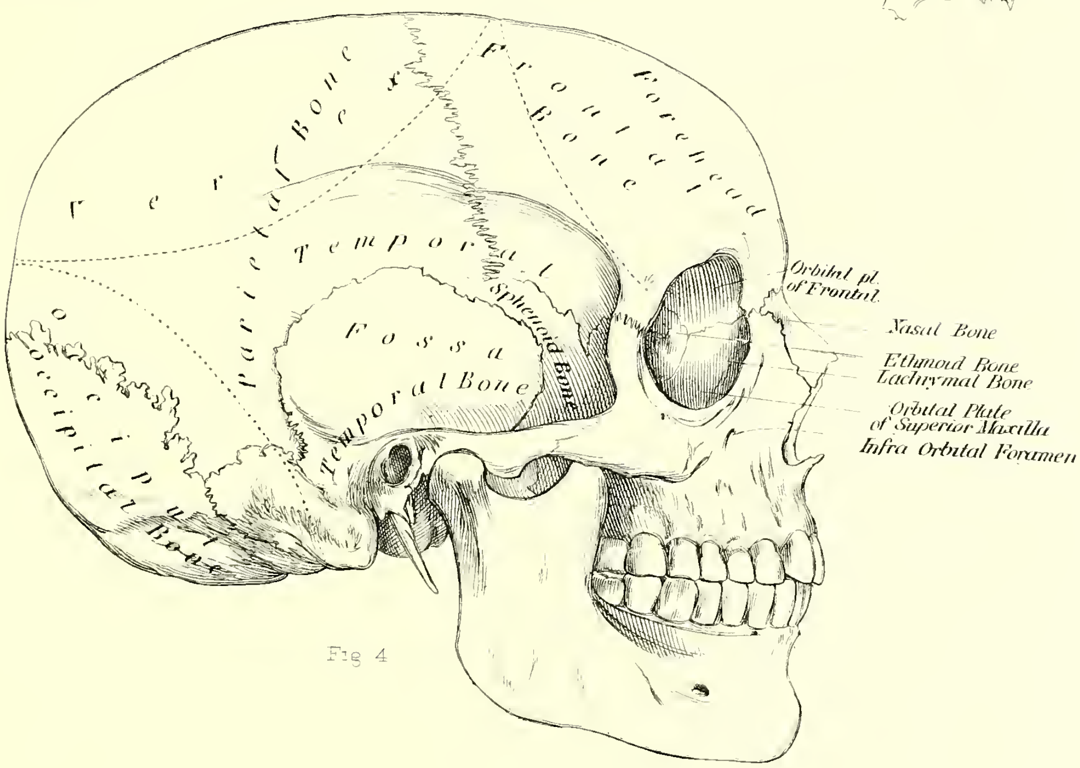


Fig 4

T. Sinclair & Son Lith.

constitute the anatomical features of the internal base of the skull.

The *exterior* base is the exterior of the parts forming the interior base. It is that surface remaining after the face has been removed. Anteriorly at the base of the forehead it is angulated to answer to the difference in level between the anterior and the middle cerebral fossæ of the interior base. The horizontal plates of the frontal bones and the cribriform plate of the ethmoid bone form one line of the angle, and the anterior (orbital) surfaces of the greater wings of the sphenoid bone the other. At the inferior border of the latter, namely, at the superior border of the spheno-maxillary fissure of either side, an imaginary line drawn backward to the posterior border of the foramen magnum (opisthon), and thence to the external occipital protuberance, completes the limitation of the exterior base. The figure resultant upon the union of these lines may be compared to a letter Z, the lower horizontal member of which is greatly prolonged. In a less exact manner a line extending from the external occipital protuberance to the fronto-nasal suture has been said to define the base.

A section made by removing the parts intervening between the lower limb of the Z and the free anterior end of the figure would pass through the roots of the pterygoid processes, the angular processes of the frontal bones, the vomer, and the perpendicular plate and ossa plana of the ethmoid bone.

Examined in detail, the exterior base of the skull presents for examination from before backward the following surfaces: The narrow and perforated cribriform plate of the ethmoid bone; the horizontal plates of the frontal, which are thin, brittle, and slightly arched, together with the orbital surfaces of the lesser sphenoidal wings; the section of the external angular process, showing spongy tissue; the smooth surface of the thick, spongy greater wing of the sphenoid bone—the junction of the horizontal and sphenoid surfaces, which is often marked by a number of minute foramina. Behind this region the body of the sphenoid bone, the bases of the pterygoid processes, the horizontal limb of the greater wing of the sphenoid, and the squamous portion of the temporal bone, are seen. Yet more posteriorly lies the cranio-basic axis, as here represented by the basilar portion of the occipital bone. The lateral portions are composed of the under surface of the petrous portions of the temporal bones and of the tympanic bones. The posterior basal surface is made up of the foramen magnum, of the occipital condyles, of the lateral portion of the occipital bone, and of the ascending portion of the same as far as the superior semicircular line.

The exterior base of the skull is marked by the lateral processes of the frontal bone, by the pterygoid, the spinous, styloid, mastoid, and jugular processes, and by the occipital condyles. It presents for examination the following fossæ: the pterygoid, scaphoid, glenoid, digastric, and the depressions in front and behind the occipital condyles.

The exterior base is pierced by the optic, anterior lacerated, oval, spinous, and posterior condyloid foramina. It receives the termination of the hypoglossal canal and the beginning of the carotid canal.

The structure and openings defined by the union of parts entering into the exterior base are: First, the *anterior lacerated foramen* between the greater and lesser wings of the sphenoid bone. It looks directly forward. Secondly, the Eustachian sulcus—extending inward and forward from the inner end of the glenoidal fissure to the body of the sphenoid bone. It is formed in part by the sphenoid and in part by the petrous portion. Its base is often incomplete. Thirdly, the *median lacerated foramen;* this is an interval between the tip of the petrous portion and the body of the sphenoid bone. It is occupied by fibro-cartilage during life. It is of variable size, and in the long and narrow skulls, as the skull of the negro, may be absent. Fourthly, the *petro-basilar groove.* This is a depression lying between the petrous portion and the outer side of the basilar process. It is filled with fibrous tissue during life, and is continuous with that filling up the median lacerated foramen.[1] Fifthly, the *posterior lacerated foramen.* This is formed by the union of the jugular grooves of the petrous portion of the temporal and the jugular groove of the occipital. It transmits the jugular vein, and the ninth, tenth, and eleventh cranial nerves. A bony septum (inter-jugular process, Henle) often separates the nerves from the nerve veins.

The posterior lacerated foramina and the jugular fossæ vary greatly in size in different individuals, and on opposite sides of the same individual.[2] A number of hypotheses have been from time to time announced according to which a definite connection between the size of the foramina and the activity of the brain centres and the special organs is traced. It has been claimed[3] that the foramina are contracted in

[1] The median lacerated foramen is not to be confounded with the termination of the carotid canal seen within the middle cerebral fossa.

[2] Theile, Zeitschr. für Rationelle Medicin, 1855, 339; F. O. Ward, Outlines of Human Osteology, 58; T. Dwight, Am. Journ. of Med. Sci., Oct. 1873; Rüdinger, Monatsch. für Ohrenheilkunde, 1875.

[3] Kasloff Oppenheim, Zeitschr. für die gesammte Med., Jan. 1844—abstract in Amer. Journ. of Med. Sci., 1844, 209, vol. viii.

maniacs and in suicides; and that subjective noises in the ears are at times associated with a narrowed foramen, especially when a wide bulbus of the jugular vein exists. An eddying current of blood is hereby created, it is thought, the sound of which is conducted to the labyrinth.[1]

The *carotid canal* is defined only when the bones are articulated. The inferior orifice is confined entirely to the petrous portion of the temporal bone. The superior orifice lies above the petro-basilar fissures at the middle lacerated foramen, as seen upon the interior base.

The base of the skull, as has been seen from the foregoing, will have connection with the face through the horizontal plate of the frontal bone, with the pharynx through the basilar portion of the occipital and the body of the sphenoid bone, and with the neck in the region behind the foramen magnum.

The base has been divided by writers on topographical anatomy by regions answering measurably to the above subdivision. Thus the palatal or facial—guttural or pharyngeal and occipital portions are described. But in practice little or no advantage accrues from following such an arrangement of parts. In seeking for the lesions of fracture, it is true, the base may be considered as a whole, but for all other clinical purposes it is best to ignore it. The palatal region is included in the face; the occipital becomes post-atlantal, and is included in the region of the neck. The so-called guttural region forms the base of the skull as distinguished from the adjacent regions.

Clinically restricted, when a tumor is stated as having its origin at the base of the skull, that portion immediately above the pharynx is intended. For the location of disease at the base of the skull the following division will be found worthy of consideration. By connecting the apices of the mastoid processes a line will be described which traverses each of the occipital condyles at its middle. This line will include the points of insertion of the muscles turning the head, as well as the region of the fulcrum at which the motion occurs. Behind and in front of this line lie the muscles which bow and retract the head. It therefore represents a region to be specially studied in all cases in which impairment of motion of the head or of the neck is a conspicuous sign. A second line extending forward from the digastric groove of the mastoid process to the inner plate of the pterygoid process will lie directly to the inner side of the oblique line of processes—the styloid, vaginal, spinous—and will retain all the foramina. Thus the jugular foramen and the beginning of the carotid canal lie directly upon the line, while the spinous and oval foramina lie immediately to the outer side. This line divides the under surface of the petrous portion of the temporal bone into two natural parts; the part to the lateral side of the line is related to the front of the neck and the face; that to the median side is connected with the pharynx. A tumor located at the lateral side of the line would involve the cheek-tissue, and in all likelihood be excluded from the base of the skull by the recorder. One arising from the median side would be as certainly described as connected with the base of the skull.

[1] S. Moos, Archiv of Ophth. and Otol., v. 478.

The Sutures of the Base.—The sutures of the base include the cranio-facial sutures; the *squamoso-sphenoidal* is seen traversing the zygomatic fossa; this division of the *squamoso-sphenoidal* suture is observed to be continuous with the *squamoso-tympanic* suture at the glenoidal fissure; in the median line is the *basilo-sphenoidal* suture. The straight, non-serrate *petroso-sphenoidal* suture lies at the bottom of the sulcus for the cartilaginous portion of the Eustachian tube. Next in order is the *petroso-basilar* suture at the bottom of the groove of the same name. It is a nearly straight, smooth junction. The horizontal limb of the *occipito-mastoid* suture is next seen. It is a nearly straight sutural line extending from about the centre of the digastric groove to the posterior lacerated foramen.

Structure.—In the occipital bone between the condyles and the jugular processes, in the petrous portion of the temporal bone in great part, and in the horizontal portion of the greater wings of the sphenoid the base of the skull is compact. It is spongy in the occipital condyles, in the basilar processes, in the pterygoid processes in great part, and in the jugular and the mastoid processes. The last two processes, together with the posterior projection from the base of the pterygoid processes bordering upon the middle lacerated foramen, are noticeable for the coarseness of the interspaces.

In fractures of the skull, the under surface of the frontal lobes of the brain and the rounded end of the spheno-temporal lobes are often found torn and bruised, even when the lines of fracture do not correspond to the seats of brain-lesion. This is not likely to occur under the cerebellum or pons, owing to the large lymph-cavities there present.

REMARKS.—For all practical purposes, the basilar process and the body of the sphenoid bone form one structure, which may be called the cranio-basic axis. The spongy tissue here situate is often the seat of ostitis. It is found by surgical writers to be liable to caries, particularly that portion of it composing the body of the sphenoid bone. Caries originating in this locality will often involve the nasal chamber and excite inflammation of the pharynx, into which chamber particles of bone may be discharged.

Disease rarely attacks both base and vault in the same subject. If the vault is involved, the base escapes, and *vice versa.*

Pressure exerted from the accumulation of fluid in the descending horn of the lateral ventricle, as from hydrocephalus, creates distortion of the sides of the middle cerebral fossa, and, if the condition of the sutures permit, rotation of the temporal bone outward and downward, with resultant deformation of the basis of the skull and the side of the face. In such cases the external meatus lies on the base of the skull close to the occipital condyles, and a lateral pouch encroaches upon the sides of the face.[1]

In cretinism the deformations are in their initial forms basal, and pertain to errors of development and trophic change in the bones arising from cartilage at the cranio-basic axis. The cancellated structure of the basilar process of the occipital bone is exaggerated; the sphenoidal sinus is enlarged or malformed; the dorsum sellæ is steep; and the inclination of the plane of the basi-axis is variously changed from the normal plane. Accessory to these deviations, and in a measure dependent on them, ensue modified facial proportions and dental irregularity.[2]

THE CRANIO-FACIAL, OR INTERMEDIATE PORTION OF THE SKULL.

The union of the cranium and the face is effected at four places: at the zygoma, at the junction of the malar and temporal bones; at the outer wall of the orbit, at the junction of the frontal and malar bones; at the pterygo-maxillary junction, between the superior maxilla, palatal, and sphenoid bones; and finally at the junction between the vomer, the perpendicular plate of the ethmoid bone, and the bones articulating therewith (figs. 1 and 2, Plate XXIV.). Resulting from these lines of union a region is imperfectly defined on the exterior base of the skull, which may receive the name of the *cranio-facial region*, since its parts cannot be defined without including bones common to both the cranium and the face.

This region lies medianly to the zygomatic arch, and embraces two fossæ, the *zygomatic fossa* and the *spheno-maxillary space* (fig. 1, Plate XXIV.); and two fissures, the *pterygo-maxillary* and the *spheno-maxillary.*

The *zygomatic fossa* is bounded in front by a line produced downward from the under free border of the malar process of the superior maxilla; behind by the posterior free edge of the external pterygoid plate; below by the alveolar process posterior to the second molar tooth; and above by the ridge separating the Temporal from the External Pterygoid muscles. The bottom of the fossa is composed of the tuberosity of the superior maxilla, and the outer surface of the external pterygoid plate. Above it admits the horizontal portion of the greater wing of the sphenoid bone. It is continuous above with the temporal fossa and the orbit; behind with the exterior base of the skull; below, when the lower jaw is in position, with the parts about the coronoid process of the lower jaw; and medianly with the spheno-maxillary space.

The *spheno-maxillary space* (spheno-maxillary fossa) is the space between the free anterior surface of the upper half of the pterygoid process behind; the median part of the tuberosity of the superior maxilla, and a small portion of the orbital process of the palatal bone in front; and the outer wall of the nasal chamber (where it is defined by the thin and weak vertical plate of the palatal bone) within. The space has the form of a narrow triangle whose base is upward, where it is continuous with the orbit at the posterior end of the spheno-maxillary fissure. It is thus limited above by the *spheno-maxillary fissure;* while the *pterygo-maxillary fissure* limits it laterally. While the two last-named fissures aid in limiting the space, they serve as means of communication with the orbit and zygomatic fossæ respectively. The median surface or floor of the space joins the nasal chamber by means of the spheno-palatine foramen.

The spheno-maxillary fissure results from the formation of the orbito-temporal septum. It has no existence in animals in which the orbit and temporal fossæ are continuous, as in the dog and the lower animals generally.

At the base of the skull the position of the cranio-facial portion is indicated by the junction of the vomer with the body of the sphenoid. Clinical writers recognize that the relations of the rostrum of the

[1] Prescott Hewett, St. George's Hosp. Rep., i., 1866, 25, figs.

[2] F. V. Zillner, Nova Acta, l. c., xxvii., with figures; R. Virchow, Untersuchungen über die Entwickelung des Schädelgrundes, 1857.

sphenoid are with the pharynx, while those of the ethmoid spine are with the nasal chamber. Indeed, the anterior surface of the body of the sphenoid, including the sphenoidal sinuses, is as much facial in its relations as it is cranial.

REMARKS.—The spheno-maxillary space will readily receive prolongations of tumors originating in the nasal fossa after the thin vertical plate of the palatal bone has been absorbed. Nasal polyp has been described as thus disposed; and Greco[1] has discovered a multiple form of morbid growth of obscure origin passing in the manner described from the nasal chamber to this space.

Mr. Prescott Hewett[2] describes a tumor growing from the exterior base of the skull that pushed its way through the spheno-palatine foramen into the spheno-maxillary space, and thence through the pterygo-maxillary fissure into the zygomatic fossa, and by this region round the zygomatic surface of the superior maxilla to appear upon the cheek. A specimen is preserved in Guy's Hospital, London, of a cartilaginous tumor at the base of the skull, which had advanced into the zygomatic and spheno-maxillary space. It had involved the orbits, nasal chambers, and the maxillary sinuses.

Langenbeck[3] diagnosed a fibroid tumor originating in the spheno-maxillary space, which involved the nasal chamber and naso-pharynx by passing medianly through the enlarged spheno-palatine foramen. The nasal septum was deflected to the right, and the left choana was obstructed. The mass also extended laterally to invade the zygomatic fossa, and superiorly to enter the orbit and to press the eye outward. In an operation for the removal of the tumor the parts were found enlarged to three times their normal size.

A small but noticeable crest is frequently seen on either side of the vomer, which aids in defining the posterior nares. This crest sometimes extends across the upper arc of the posterior nares so as to rest upon the sphenoidal process of the palatal bone. This outgrowth may receive the name of *the vomerine crest.* It serves to separate the roof of the pharynx from the cavity of the nose. Specimens have been met with in which the crest has shown evidences of thickening from inflammation.

[1] Archiv. de Méd., xxiii. 431.

[2] Med.-Chir. Trans., xxxiv. 47.

[3] Deutsche Klinik., 1861; also, Med. Times and Gazette, 1861 (abstract).

THE FACE.

The face (figs. 1 and 4, Plate XXII.) is that portion of the skull designed to protect the eyes, the nose, and the teeth, and in connection with the latter to define the osseous parts entering into the construction of the mouth.

The face is of a triangular figure. One of the sides answers to the exterior base of the skull in advance of the external auditory meatus, and may be called the *superior* border. Another extends from the upper margin of the orbits to the lower margin of the inferior maxilla, and constitutes the *anterior border* or *surface.* The remaining border of the figure is the *inferior*, and is defined by the lower margin of the inferior maxilla.

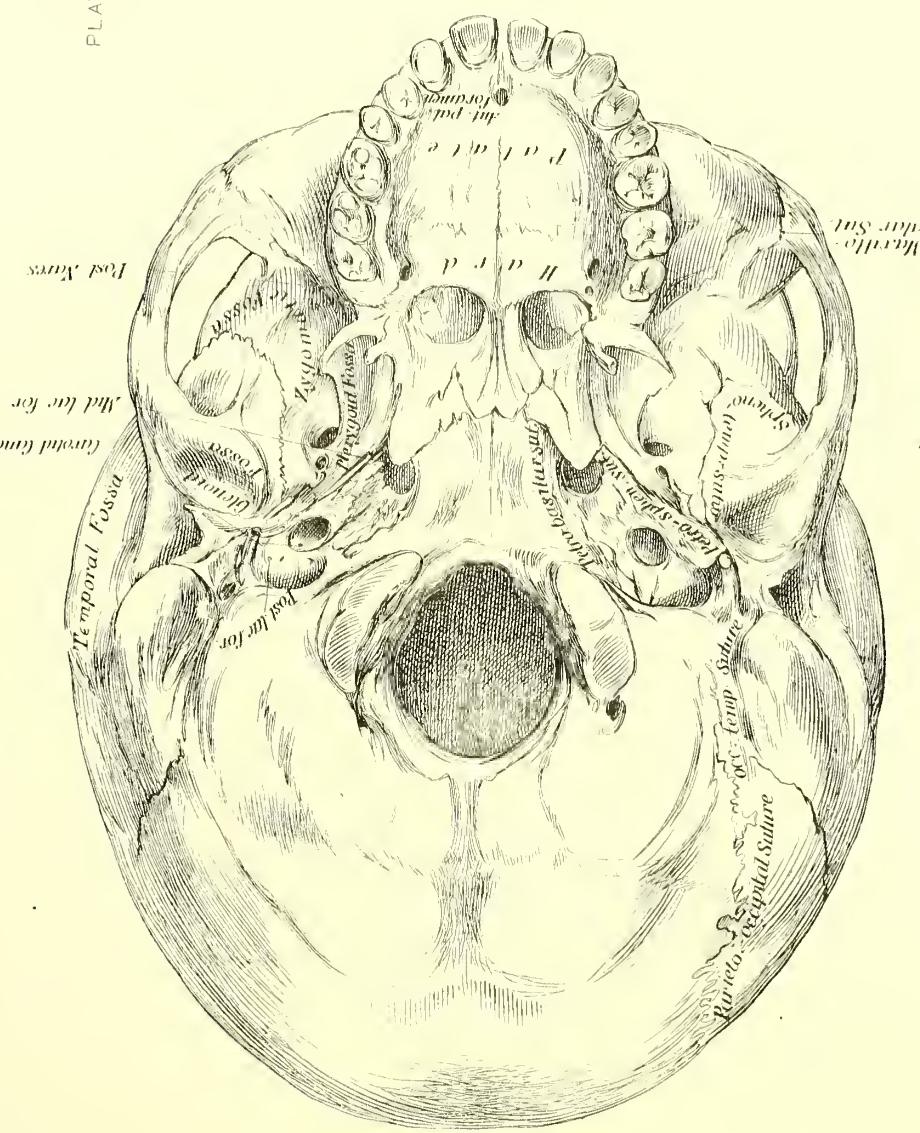
THE ORBITS.—The orbits are two conical cavities lodged for the most part in the face, but defined in part by the bones of the brain-case, and designed to accommodate the eyeball and accessory parts. Each orbit presents for examination a median (inner), and a lateral (outer), wall, a roof, and a floor.—The *median* (*inner*) *wall* is nearly straight, but slopes a little outward as it joins the floor. It is composed of the os planum of the ethmoid bone, and of the lateral surface of the lachrymal bone.—The *lateral* (*outer*) *wall* is more obliquely placed to the median line of the face than is the inner. It is composed in great part of the orbital surface of the greater wing of the sphenoid bone. In advance of this surface lies the frontal process of the malar bone. The outer wall is defined inferiorly in part by the spheno maxillary fissure.—The *roof* of the orbit is slightly concave. It is composed of the orbital plate of the frontal bone, excepting at its apex, where a small portion of the lesser wing of the sphenoid bone is lodged.—The *floor* of the orbit is continuous with the median wall, but separated from

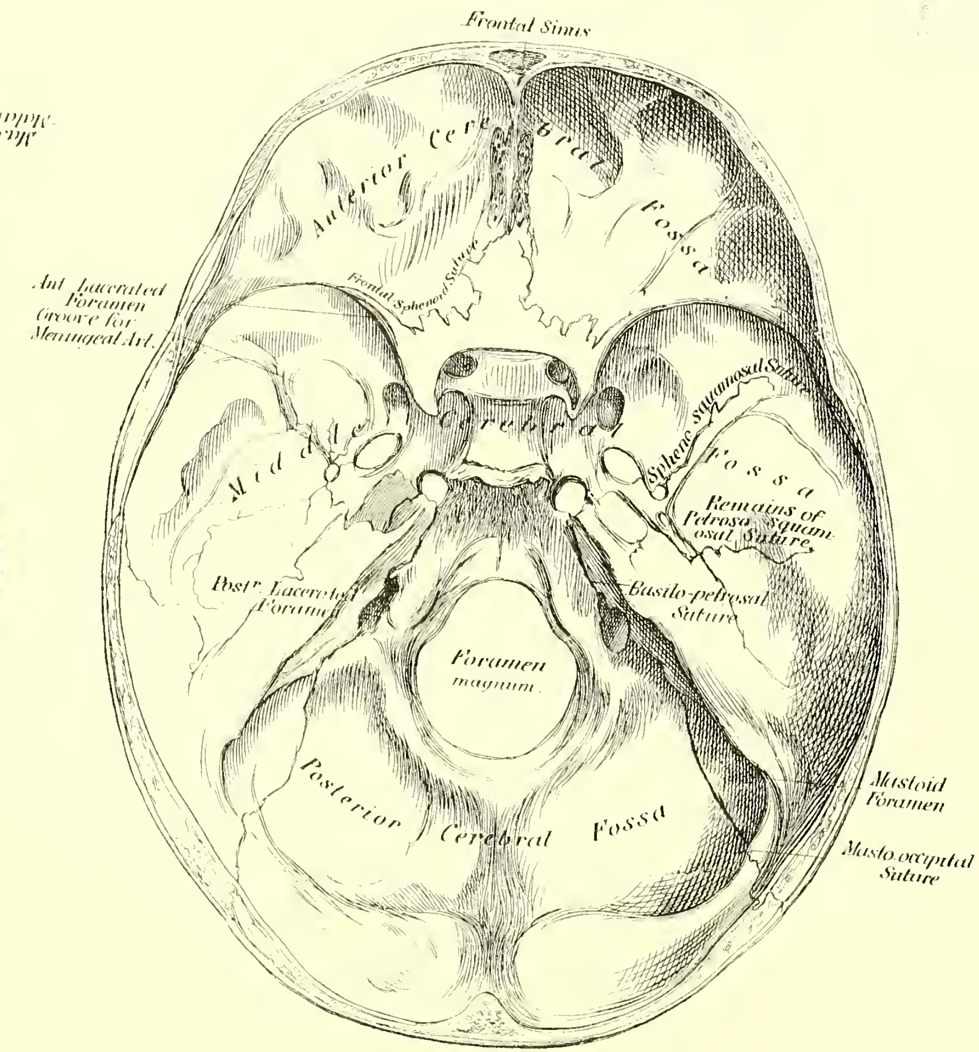
EXPLANATION OF PLATE XXIII.

Fig. 1. The skull, seen from beneath (exterior base).

Fig. 2. The base of the skull, seen from within (interior base).

PLATE XXIII


Temporal Fossa
Carotid Canal
Mid lac for
Post Nares
Glenoid Fossa
Zygomatic Fossa
Pterygoid Fossa
Post lac for
Palate
Hard
Ant. pal. foramen
Petro-basilar sut.
Petro-sphen. sut.
Temp.-sphen.
Spheno
Maxillo Malar Sut.
Occ. temp. Suture
Parieto-occipital Suture


Frontal Sinus
Anterior Cerebral Fossa
Frontal Sphenoid Suture
Ant. Lacerated Foramen Groove for Meningeal Art.
Middle Cerebral Fossa
Spheno squamosal Suture
Remains of Petrosa Squamosal Suture
Postr. Lacerated Foramen
Basilo-petrosal Suture
Foramen magnum
Posterior Cerebral Fossa
Mastoid Foramen
Masto occipital Suture

the lateral wall the greater part of its length by the spheno-maxillary fissure. In front the floor is completed by the malar bone, and behind by the orbital process of the palatal bone.

The orbit communicates with the cranial cavity by the optic foramen and the anterior lacerated foramen. The *optic foramen* lies at the apex of the orbit at the junction of the median wall and the roof. The *anterior lacerated foramen* extends from the median wall obliquely outward and inward along the junction of the lateral wall and the roof.—The orbit communicates with the temporal fossa through the spheno-maxillary fissure. The *anterior* and the *posterior ethmoidal* foramen are found at the junction of the median and lateral walls. The anterior ethmoidal foramen transmits the anterior ethmoidal artery and the nasal nerve; the posterior ethmoidal foramen transmits the posterior ethmoidal artery.

THE NASAL FOSSÆ.—The nasal fossæ (fig. 2, Plate XXIV.) are two irregular cavities, one on either side of the septum. Each fossa is narrowed above, is higher before than behind, and presents for examination a lateral and a median wall, a roof, a floor, and an anterior and a posterior aperture.—The lateral wall is exceedingly complicated. It is composed of processes of the nasal aspect of the lateral mass of the ethmoid bone, of the inferior turbinated bone, and of the nasal aspect of the body and the ascending process of the superior maxilla. The lateral wall is uneven by reason of the position of the superior and middle turbinated bones (see the Ethmoid Bone, p. 131), as well as by the position of the inferior turbinated bone. The *middle meatus* is seen to be well defined between the lower margin of the middle turbinated bone and the upper margin of the inferior turbinated bone, and the *inferior meatus*, between the lower margin of the inferior turbinated bone and the floor of the nose. Under the term *agger nasi*, Meyer describes a crest extending from the upper margin of the middle turbinated bone forward along the lateral wall. The *median wall* of the nasal chamber is the nasal septum. It is composed of the following parts named in the order of their importance; the perpendicular plate of the ethmoid bone, the vomer, the maxillary and the palatal crests, and the frontal spine. The upper two-thirds of the inner wall is derived from the ethmoid bone. In the undissected subject the triangular cartilage completes the median wall anteriorly. Rarely if ever straight, the median wall inclines commonly to the left side at the vomero-ethmoidal junction. Occasionally it is incomplete.—The *roof* of the nasal chamber is very irregular. Anteriorly, *i.e.*, in advance of the cribriform plate, it is oblique from before backward and from below upward, and is composed of the nasal bone and the spine of the frontal bone. The cribriform plate occupies the middle third of the roof or more. It is straight or slightly concave. The remaining portion of the roof is derived from the sphenoid bone.—The *floor* is shorter than the roof, and is composed of the upper surfaces of the horizontal plates of the superior maxilla and the palatal bone. It is inclined slightly from before backward, and the premaxillary portion is often elevated above the level of the remaining portion.—The *anterior nasal aperture* (anterior nares) is a pear-shaped opening defined below and at the sides by the superior maxillæ, and above by the nasal bones. It thus forms the common opening to both nasal chambers.[1] Its plane is directed slightly obliquely from below upward and from behind forward. Its apex is on a level with the superior meatus and the sphenoidal sinus.—The *posterior nasal aperture* (posterior naris, choana) is smaller than the anterior by about one-fourth its height, and is defined without by the pterygo-palatine junction, within by the vomer, above by the vomerine crest (see p. 133) and the sphenoidal process of the palatal bone. The plane of the posterior nasal aperture is oblique from below upward and from before backward.

Each nasal chamber, in addition to the communication already mentioned, joins the orbit by the *ductus ad nasum*, the zygomatic fossa by the spheno-palatine foramen, and the brain-case by the foramina of the cribriform plate. It receives the outlet from the maxillary, frontal, and the sphenoidal sinuses, as well as the ethmoid cells.

For clinical purposes, the nasal fossæ are capable of being divided into three portions: the premaxillary, the maxillary, and the palatal portions. These names are selected from the surfaces occupied by the bones entering into the composition of the hard palate and the lateral walls of the nasal fossæ answering to the same. Thus, the *premaxillary portion* of the fossa lies in advance of the anterior palatal canal, and all the parts of the lateral wall in advance of the anterior border of the cribriform plate. The *maxillary portion* answers inferiorly to the surface between the anterior palatal canal and the suture between the maxilla and the palatal bones on the hard palate, and superiorly to the posterior border of

[1] When it is intended to name the outlet of a single chamber, the term *anterior naris* or *posterior naris* is permissible.

the cribriform plate. The *palatal portion* lies between this line and the plane of the posterior nares.

The Hard Palate.—The hard palate (fig. 2, Plate XXIII.), or roof of the mouth, is composed of the palatal aspect of the premaxillæ and the palatal plates of the superior maxillæ and of the palatal bones. The hard palate is of a U-shape, the limbs of the figure being slightly divergent. In the negro, the free hinder ends tend slightly to approach one another. The posterior free border is composed of two emarginate surfaces united at a median point, called the *posterior palatal process* or *spine.* The posterior palatal process may be absent when a triangular notch is seen in its place, or the two emarginations of the palatal bones are continuous with each other without interruption. The hard palate, when divided transversely (frontal section), exhibits the form of an arch, of which the pillars are constituted by the alveolar processes, and the top by the parts above named. At the median line, the hard palate behind the premaxillary portion is thicker than elsewhere. Occasionally a pronounced median swelling or flat ridge is seen, which forms a conspicuous projection, detectable with ease even in the living subject. On either side of the median ridge the hard palate is thin, and may be diaphanous. At the junction of the hard palate with the alveolar process a conspicuous longitudinal groove is seen for the accommodation of the palatine arteries and nerves. The hard palate is pierced anteriorly by the *incisorial foramen* so called. To speak accurately, two incisorial foramina, situated one on either side of the nasal septum, so far unite as to present but a single opening upon the hard palate. Each foramen transmits the anterior palatal branch of the superior maxillary nerve, as well as a small artery, the anterior palatine of its own side. Near the posterior border and at the base of the alveolar process, is the *posterior palatal foramen* for the posterior palatal artery and nerve. This foramen is protected in a measure by adjacent rugosities, and by a strong buttress-like ridge of the palatal bone. The hamular processes of the sphenoid bone can be readily felt in the living subject by passing the finger back of the wisdom tooth a little to the median side of the alveolar process. They serve as guides to the posterior limitation of the hard palate.

The Inter-orbital Space. — The inter-orbital space includes the nasal bones, the ascending processes of the superior maxillæ, the frontal bone below the level of the supra-orbital arches, and the lachrymal bone as far as the lachrymal crest. The *ductus ad nasum* thus pertains to the superficies of the face rather than to the orbit. The conjunction of the frontal and nasal bones and the ascending processes of the superior maxillæ in this space is such that enormous strength for resisting pressure and sustaining weights results. Fracture, or other injury, is rare here. Yet the lower half of the nasal bone is not infrequently either fractured or displaced. Ivory exostoses, for some unexplained reason, arise occasionally from the line of union of this space with the orbit.[1]

At a superficial glance, the modifications of the face, in order to accommodate the teeth, are restricted to the alveoli. But a more careful examination will show that the entire facial region is adapted to the forces employed in using the teeth. It has been seen that the bones of the face, with the exception of the lower jaw, are immovably united to one another and to the brain-case. To raise the lower jaw and to bring it against the upper so as to make these acts efficient in the seizing, the cutting, and the grinding of food, demand, on the part of the last-named structure, a power of so conducting the forces of occlusion as to avoid concussion of the delicate structures contained in the orbits and nasal fossæ.

The act of seizing and tearing food appears to demand greater strength than that of cutting or grinding it. The stout canine tooth conveys the shock along

[1] Consult Duka, Trans. Path. Soc. London, xvii., 256; also W. Watson, Ibid., 1868, xix., 310.

EXPLANATION OF PLATE XXIV.

Fig. 1. Skull, seen from the side, exhibiting the profile view of the base; method of union of the bones of the brain-case and the face; together with the composition of the median wall of the maxillary sinus.

Fig. 2. Sagittal section of skull; the lower jaw and skull-cap are removed.

Fig. 3. The lateral region of the exterior base of the skull, slightly enlarged.

PLATE XXIV

Fig. 1

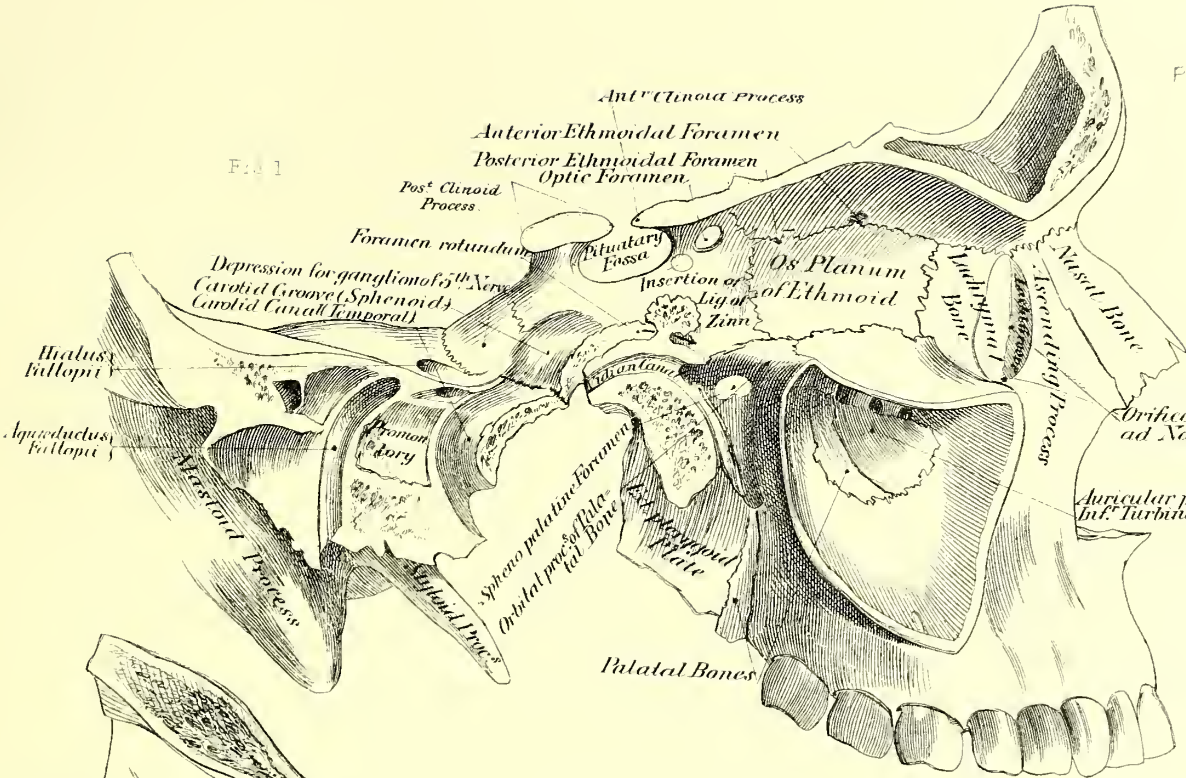


Fig. 2

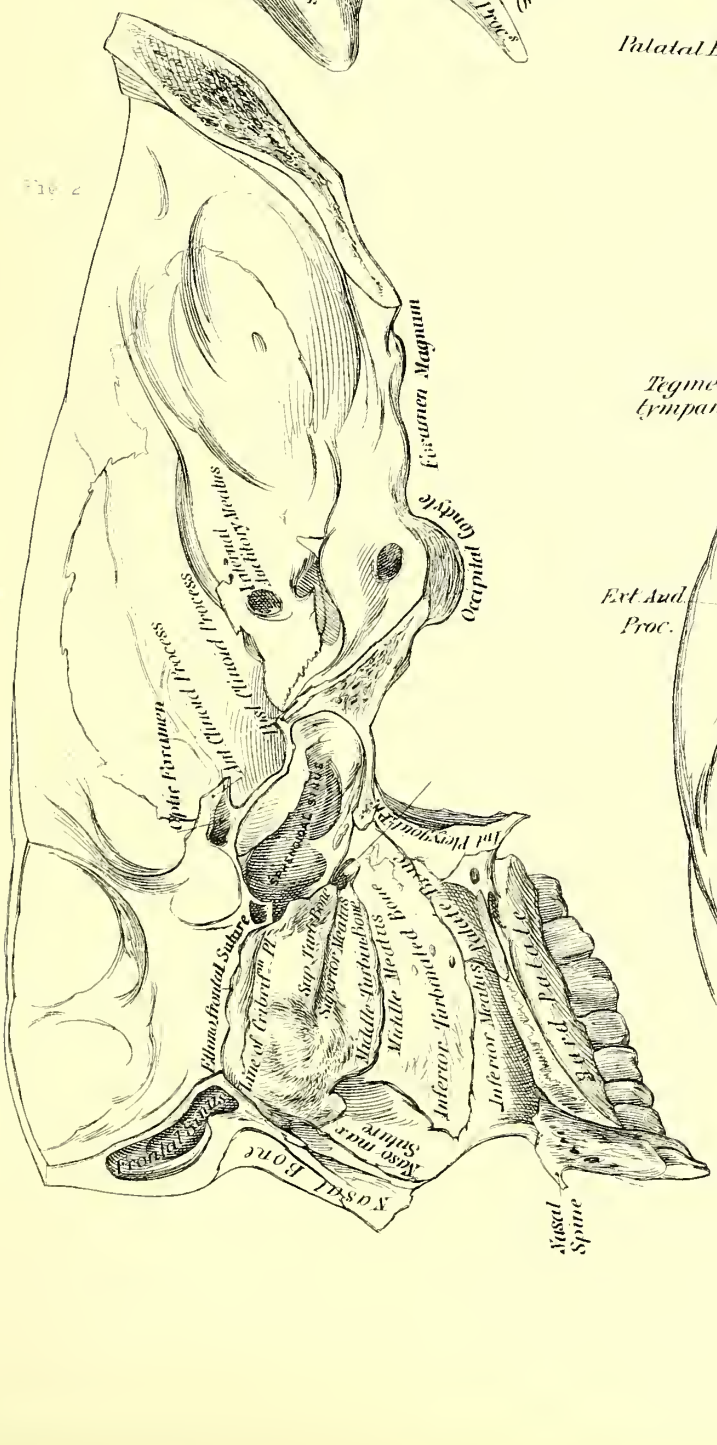
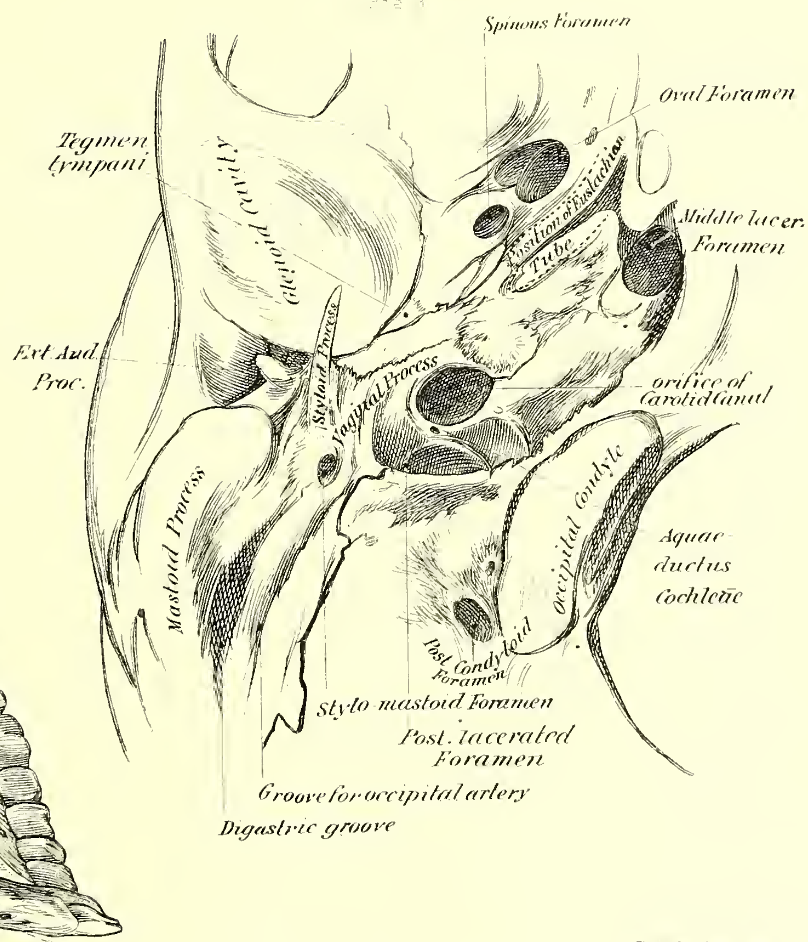


Fig. 3



the canine eminence to the ascending process of the superior maxilla, and thence it is received and distributed by the frontal bone to the cranial vault. The act of grinding demands a wide surface. This is secured by the divergent roots of the molar teeth, through which the force of the occlusion is diffused, and by the malar process, which conducts and distributes the shock to the zygoma and the cranial vault. The act of cutting demands little osseous support, and is accomplished entirely by the scissor-like action of the upper and the lower incisors against each other. The direct apposition of these teeth produces a decidedly unpleasant sensation. Disease and even death of the incisors may result from the habit (so common among seamstresses) of employing the incisor teeth in the position just named to bite off threads.

From the lines of conduction and resistance just mentioned, it is evident that there exist in the face two lines adapted to the conduction of shocks: one leading from the canine eminence through the ascending process of the superior maxilla, and the other from the malar process of the same bone to the malar bone. The spaces inclosed between the canine teeth, and between each canine tooth and the malar process of the corresponding side and the malar bones, are not adapted to convey or resist shock. It is within these spaces that the eyes and nasal organs are placed, and the nerves and bloodvessels lie. Even in the lower jaw we find in the adult the mental foramen on the same vertical line with the infra-orbital and the supra-orbital foramina. The repeated occlusions of the lower jaw against the upper may be said to maintain the shape of the latter. When the lower jaw is removed the alveolar processes fall inward, notwithstanding that the hard palate remains intact. This is well illustrated in a case reported by Ribes[1] of gunshot wound of the lower part of the face in which the lower jaw was torn away.

In extensive lesions of the face in which the lines of attachment between the immobile portion of the face and the brain-case have been severed, and yet the soft parts have been retained intact, the act of chewing becomes impracticable. The writer observed the case of a man who had incurred multiple fracture of the region of the face from a premature explosion of a blast: recovery from the immediate effects of the injury followed, but with absence of union between the face and the brain-case. The entire "upper jaw" was freely movable. The patient was sustained by liquid food. Dr. Fyffe[2] reports a case of dislocation of the bones of the face with fracture, including marked movability of the upper jaw during deglutition.

Surgical writers include in the term superior maxilla, or "upper jaw," parts embracing the palatal, inferior turbinate, and part of the ethmoid and the malar bones. The bones named are of necessity removed in the operation for excision of the superior maxilla. Viewed in this way the superior maxilla is said to be included between the inter-orbital space, the face as far laterally as the outer wall of the orbit, and the hard palate including the junction with the pterygoid process. The last-named junction is apt to be retained after complete severance at the other parts—and forcible depression of the partially detached mass is necessary before the final division can be effected.

Abernethy mentions a case in which the bones of the face were torn away from the skull, and left hanging merely by the optic nerves.

THE STRUCTURE OF THE SKULL CONSIDERED WITH SPECIAL REFERENCE TO THE EFFECTS OF INJURY.

The effects of injury upon the skull are varied by many circumstances, chief among which are the following:—

(1) The distribution of the spongy and compact tissue.

(2) The disposition of the cranial bones and their sutures.

(3) The direction from which the blow is received, as well as the position of the head at the time.

(1) *The Distribution of Spongy and Compact Tissue.*—The cranial vault is composed for the most part of *spongy tissue* overlying a thin compact layer. The spongy tissue is best developed at the occiput and at the sides of the vault. The squamæ, the sutural lines, the depressions for the Pacchionian bodies, and the forehead below the frontal eminences, are comparatively devoid of it. This spongy tissue of the vault has received the name of *diploë*. It is described as occupying the interspace between two plates, the outer and inner. The last named of these alone is worthy of the name, since the first named is inconstant in development, and may be absent. When present it is furnished with a number of minute openings for the escape of veins. The diploë is composed of a network defining irregular interspaces. These may assume a lamelliform arrangement, but are more frequently without apparent order. The diploic cells

[1] Dict. des Sciences Nat., 1818, xxix., 425.

[2] Lancet, 1863, ii., 64.

are filled with a marrow-like substance, together with some free fat. Ramifying among them are the *canals* of the diploë for the veins of the same name. The spongy tissue throughout the rest of the brain-case preserves the same general characters as that of the vault. It is well developed at the following localities: in the occipital bone at the region of the occipital protuberance, and in the median line thence to near the foramen magnum in the occipital condyles and the under surface of the jugular process; in the mastoid process; in the petrous portion of the temporal bone from the position of the posterior meatus to its tip; in the axis of the cranium from near the anterior margin of the foramen magnum to the position of the sphenoidal sinus, inclusive of the posterior clinoid plate; in the great wings and the pedicle of the external pterygoid plate of the sphenoid bone; and in the posterior pedicle of the lesser wing of the same name. In the facial region the spongy tissue is most conspicuous in the alveolar processes and the malar bones.

Compact bone-tissue is seen in the vault at the inner plate, as already mentioned. This layer is thick and smooth. It nearly corresponds to the shape of the brain, and presents at the base of the anterior and the middle cerebral fossæ a number of ridge-like elevations, which serve to give the plate increased strength. At the cranio-basic axis the inner plate is thinner than the outer. In some forms of hypertrophy the inner layer of the skull is enormously thickened; on the other hand, it may become lost in an osteoporotic condition which extends entirely through the skull-wall. Among other localities, the compact tissue is noticeable in the petrous portion of the temporal bone; in the cerebellar fossæ, the glenoid fossæ, the lesser wings and spinous processes of the sphenoid bone; and in the orbital plates of the frontal bone. Within the face all the bones entering into the nasal chamber and the walls of the maxillary sinus are papyraceous in consistence. In describing the course of the lines of fracture in the cranium, the character of the bone through which the fissures pass should receive the same attention as the direction of the fissures.

(2) *The Disposition of the Cranial Bones and their Sutures.*—The arrangement of the cranial bones and their sutures holds an exact relation to the mechanics of the skull. The union of the parietals by the interparietal suture converts the two parietal bones into an arch, the abutments of which are formed by the antero inferior and the postero-inferior angles of the bones. Between these abutments, on either side, is seen the squamosal emargination. The plan of articulation of the abutments is significant of their use. The posterior is received into a V-shaped interval at the ascending portion of the occipital bone, and the re-entering angle is formed between the squamous and the mastoid portions of the temporal bones—producing a conjunction of sutural lines named the *stellion* of Broca. At a short distance below this point lies the occipito-mastoid suture. The anterior pillar of the abutment is received upon the anterior portion of the squama, and the greater wing of the sphenoid bone at the so-called *pterion* of Broca. At the base of the skull, in the line of the anterior abutment, lies the squamoso-sphenoidal suture. Rarely, a separate suture exists at the conjunction of the horizontal and ascending portions of the greater wing. It will be thus seen that the abutments of the arch formed by the parietal bone through the junctions effected by its antero-inferior and the postero-inferior angles rest upon parts of the base crossed by sutures. These sutures are harmonic, and are among the last to disappear. It is evident that a vibration passing from the vertex to the base by either of the abutments will be diffused by the time it reaches the base. From the position of the parietal bone with its slightly oblique direction from before backward and above downward, it would appear to facilitate the transmission of vibration along the posterior abutment. The distribution of the waves of vibration from both the anterior and posterior abutments to the face, the spongy tissue of the sphenoid, and the basilar process, is so effected as to protect the brittle petrous portion of the temporal bone. It is well to recall the free, coarsely-cancellated projections already remarked upon the basal region —viz., the mastoid, jugular, and other processes—as structures well adapted to receive and diffuse vibrations.

The sutures of the skull exert a marked influence in modifying injury during infancy and in youth. In adult life, the sutures may separate as the result of violent injury, but more commonly, particularly at that period at which the sutures have disappeared, the injuries occur in great measure entirely independently of the sutures. In individuals over fifty-five years of age, the study of fracture becomes one of directions of resistance and force without reference to the position of sutures. The fissures of fracture may even traverse large foramina.

(3) (*a*) *The Direction from which a Blow is Received.*—Fracture of the base of the skull will be found to correspond to the region of the vertex which has received

the blow. Thus fracture of the orbital plate of the frontal bone may follow a blow on the vertex at the ascending portion of the same bone. To facilitate the study of lesions resulting from blows received on the vertex Prescott Hewett[1] proposes a division of the skull into three segments or zones: an anterior zone formed by the frontal, the upper part of the ethmoid, and the wings of the sphenoid; a middle zone, by the parietals, the squamous, and the anterior surface of the petrous portions of the temporals, with the greater part of the body of the sphenoid bone; and a posterior zone, including the occipital, the mastoid, and the posterior surfaces of the petrous portions of the temporals, with a small part of the body of the sphenoid.—With the skull thus divided, the lines of fracture in the less severe cases are seen to be strictly limited to one or the other of these zones.—The region of the sphenoid bone, either alone or in combination with the other regions of the base, is that in which fracture most frequently occurs. Upon it the lines of conduction from the parietal arch are converged.

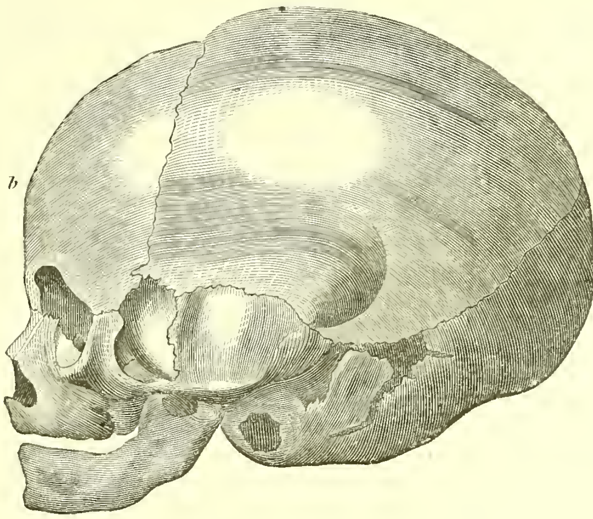
(*b*) *The Position of the Head at the Time of the Reception of the Blow.*—Some of the vibrations of blows received upon the vertex the skull will conduct either through the cranio-basic axis or the vertebral column. The manner in which this is accomplished will vary according to the position of the head at the time of the reception of the blow. The occipital condyles rest upon the atlas, and it is seen that each condyle is placed obliquely to the base of the skull, and consequently to its axis. Its anterior portion is thick, its posterior is thin. The weight of the skull tends inevitably to press the condyles within the concavity of the atlas, and it follows that the line of this pressure will be downward and inward, and more at the anterior part of the condyle than at the posterior. The convergence of the condyles tends to effect a union of the lines of support and to transfer them from the condyles to the axis of the skull; so in effect the basilar process and the body of the sphenoid bone receive the weight of the skull plus that of the face. The skull, however, is not balanced upon the vertebral column, but inclines to drop forward. This tendency is made necessary by the action of the post-cervical and the Sterno-Cleido-Mastoid muscles.

THE SKULL CONSIDERED IN RELATION TO AGE.

The description of the skull, as usually accepted, applies to that of the adult only. Numerous modifications of the account given in the preceding section are required to properly define the skull before development is complete, or after old age has set in. Two types will be especially mentioned in this connection. These may be called *the skull at birth*, and *the skull in extreme old age.*

The Skull at Birth.—The skull presents conspicuous prominences at the centres of ossification of the parietal and the frontal bones; the region of the occipital pro-

Fig. 68.



tuberance is markedly convex. The sutural lines are straight or nearly so. The fontanelles are all present. The skull presents many negative features, such as the absence of basal processes—the pterygoid processes alone excepted; the external auditory meatus is undeveloped; the jaws are edentulous, and the alveolar processes absent; the glenoid fossa is shallow, and affords little protection to the condyloid process of the inferior maxilla; the sinuses are rudimentary or absent. The peculiarities of proportion are numerous. The face constitutes but one-eighth of the entire figure, instead of nearly one-half in the adult. This is chiefly owing to the imperfect vertical growth of the bones. The orbits present deep depressions for the lachrymal glands. The entire cranium, as compared with the trunk, is large. Its length from the forehead to the occiput is great, as compared to its breadth. The breadth is great from one parietal protuberance to the other in proportion to the height. The brain-case is shallow in comparison with its capacity anteriorly and posteriorly. The orbit is much less deep at the median wall in the infant, owing to the imperfect descent of the median structures of the face; the proportions of the lateral wall are about as in the adult.

[1] Holmes's System of Surgery, vol. ii.

The Skull in Extreme Old Age.—The skull in old age presents many distinguishing features. The sutures are nearly or entirely lost (see p. 156). The walls of the brain-case are ordinarily thin from atrophy, while the teeth are absent and the alveoli absorbed. The skull is much lighter than in the mature adult, and the weight of the face is materially lessened. As a consequence, the skull is more readily balanced upon the vertebral column, thus making up for the withdrawal of the muscular power so essential to the maintenance of the head in man in his prime. The spheno-orbital septum, the roof of the tympanum, the orbital plate of the frontal bone, the os planum of the ethmoid, may be perforated. Other small processes, such as those tending to close the orifice of the maxillary sinus, may disappear. The pterygoid process is straighter than in the adult, and flattened in front. Owing to the absorption of the tooth-pits, it may descend far below the level of the hard palate. The prominence of the hamular process in consequence can be felt within the mouth during life. The outer pterygoid plate is often widened and extended some distance downward along the plane of the lower fibres of the External Pterygoid muscle. The triangular cartilage of the nose is often ossified; the sinuses are generally enlarged, though these may be even smaller than in the adult; and the jugular process is enlarged and inflated.

THE HYOID BONE.

The hyoid bone (figs. 1, 2, Plate XXV.), so called from its resemblance to the Greek letter *v*, lies in the region of the neck between the tongue and the larynx, with its convexity directed forward and its concavity backward. It is superficial, permitting the general outline of the bone to be traced beneath the skin in the undissected subject.

The hyoid bone is composed of a body and two pairs of processes.—The *body* is somewhat quadrilateral in form, and is nearly twice as wide as high. The anterior surface is convex and well marked at the upper half by muscular impressions for the Genio-Hyoid muscles. These impressions look upward, and are sharply separated from the rest of the anterior surface which looks directly forward. The compressed median interval between these impressions is sometimes prominent and ridge-like. The posterior surface is smooth and deeply concave. The upper border is thin, and continuous with the inner and upper margin of the greater horn. The lower border is thicker than the superior, and is obscurely angulated laterally at the place of origin of the Omo-Hyoid muscles. The lateral border being continuous with the greater horn is seen only in the undeveloped bone.

The processes are two in number on each side, and have received the names of the greater and the lesser cornua or horns.

The *greater horn* is a long, irregularly club-shaped process, which is directed upward and backward, and is gradually narrowed posteriorly to end in a bulb-like tip.—The *lesser horn* is a small, peg-shaped nodule, ascending nearly at a right angle from the plane of junction of the body and the greater horn laterally. A joint ordinarily exists between the process and the rest of the bone.

The hyoid bone gives attachment by its lower border to the thyro-hyoid membrane; by the tip of the greater horn to the thyro-hyoid ligament; by the tip of the lesser horn to the stylo-hyoid ligament. In addition to the Genio-Hyoid and Omo-Hyoid muscles already mentioned, it gives origin to the Hyo-Glossus, Middle Constrictor, Sterno-Hyoid, Sterno-Thyroid, and Thyro-Hyoid muscles, and insertion for the Mylo-Hyoid, and Stylo-Hyoid muscles.

Development.—The hyoid bone arises from five centres of ossification, one for the body and one for each of the horns. The centres for the body and the greater horns appear in the ninth month of fœtal life. The centre for each of the lesser horns appears during the first year. The lesser horn remains cartilaginous until advanced life.

Remarks.—The greater horns of the hyoid bone are rarely exactly similar. The left lesser horn is so

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EXPLANATION OF PLATE XXV.

Fig. 1. The hyoid bone, seen from above.
Fig. 2. The hyoid bone, seen from in front.
Fig. 3. The thorax.
Fig. 4. The sternum and the costal cartilages, seen from in front.

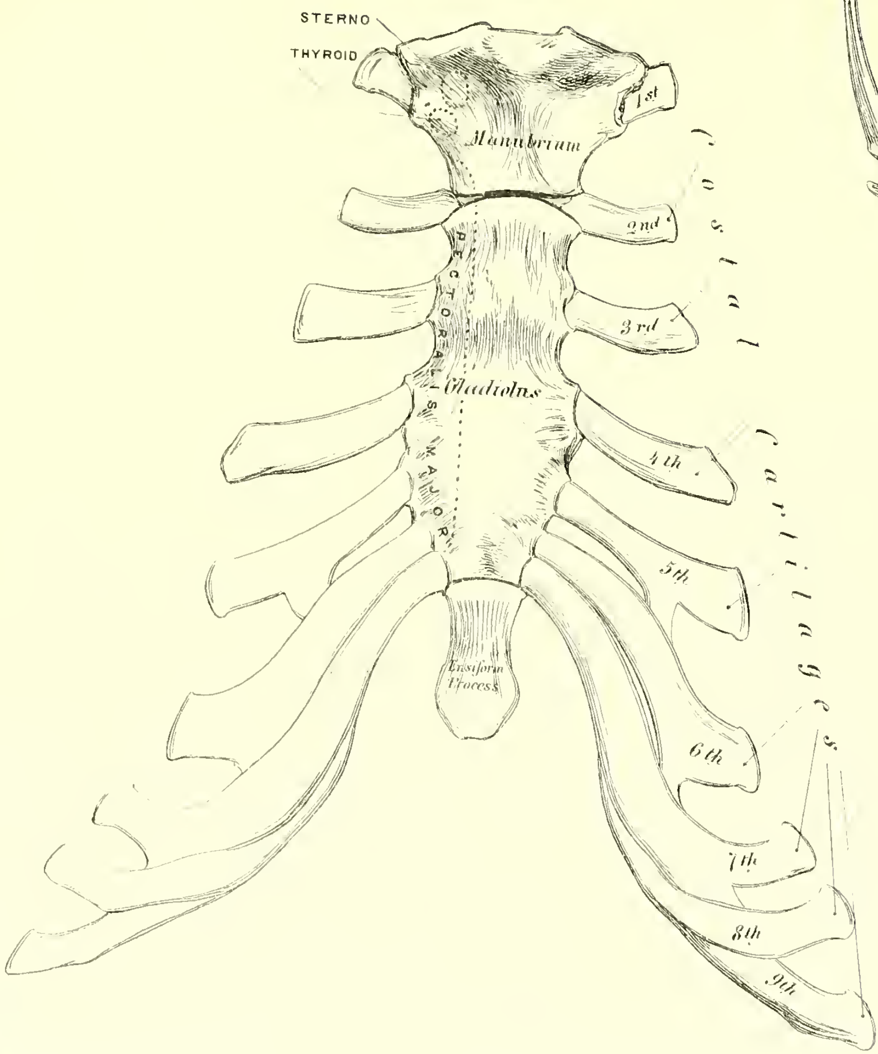


Fig. 1

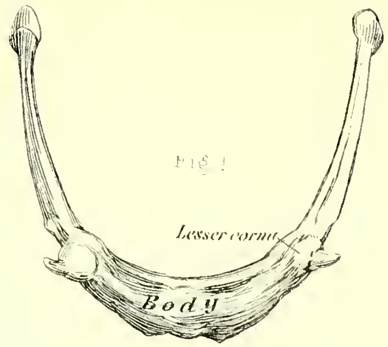
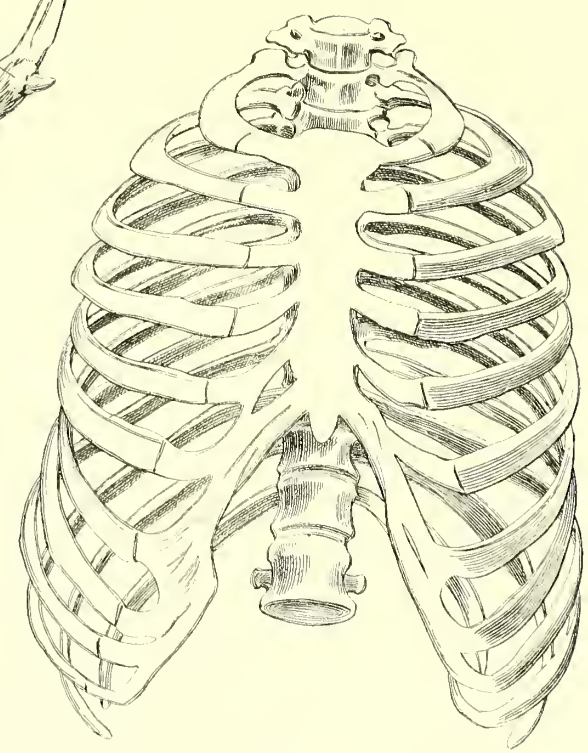


Fig. 3



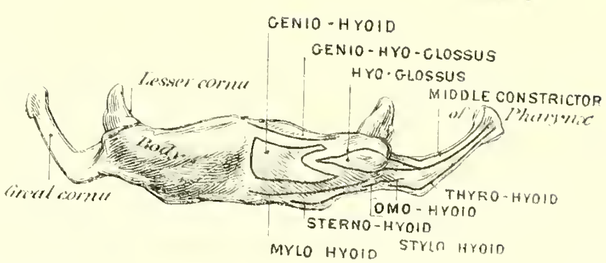


PLATE XXV

often longer than the right that some authors have described such a condition as normal.—The hyoid bone is raised in the second portion of the act of deglutition, but falls at the end of that act. It is depressed by the action of the Sterno-Thyroid, the Thyro-Hyoid, the Omo-Hyoid, and the Sterno-Hyoid muscles. The greater cornua serve to keep the laryngo-pharynx patulous in the way that the blades of a glove-stretcher act on a finger of a glove. Directly behind the body lie the fatty fibrous tissues about the base of the epiglottis.—From the movability of the bone it is capable of being displaced by tumors. Gibbs[1] describes a tumor arising from the thyroid cartilage, producing such displacement. Retro-pharyngeal abscess at the portion of the pharynx answering to the plane of the hyoid bone has also been known to displace the cornu of the corresponding side, and to produce conspicuous deflection of the larynx from the median line.—Grasping the throat at the position of the hyoid bone may, by the forcible approximation of the greater cornua toward each other, cause either fracture or disjunction of its several parts. The bone may be also fractured in execution by hanging.

THE RIBS.

The ribs (figs. 4 and 5, Plate XXVI.; fig. 3, Plate XXV.) are those curved flat bones extending from the spine to the costal cartilages. They are twelve in number, and form a series of narrow arches which make up the lateral, the posterior, and in part the anterior, boundaries of the thorax. These arches are either prolonged by the costal cartilages to the sternum, when the ribs entering into them are called the *true* or *sternal ribs*, or they fail to join the sternum, when the ribs entering into them are called the *false* or *asternal ribs*. The true ribs are those included between the first and the seventh; while the false ribs make up the remaining five. Of the latter the eighth, the ninth, and the tenth are connected by their costal cartilages, and are held to one another as well as to the cartilage of the seventh rib. The eleventh and twelfth ribs are without fixation, and are from this circumstance known as *the floating ribs*. At times the tenth costal cartilage remains unattached to the ninth, when the number of floating ribs is three.

The classification of the ribs into the true and the false, and the restriction of the last two ribs to a separate group, are in some respects unsatisfactory. In a proper sense all the ribs are true ribs, since they vary only in the single feature of the degree of fixation of the anterior ends. Sibson[1] very properly says that it is in the dead body only that the "floating ribs" can be said to float; for in the living body they are steadied by powerful respiratory muscles. While the task of criticizing the nomenclature of the ribs is an easy one, attempts to improve upon the nomenclature have not been successful. Sibson[2] proposes the term *diaphragmatic ribs* to include the last four, since these are moved actively by the Diaphragm, the other ribs being termed by him the *thoracic*. Why all the ribs are not thoracic is not made clear by this arrangement, nor is it reasonable to omit the sixth and seventh from the diaphragmatic ribs.

Since the first six ribs present convex lower borders, give origin to the Pectoralis Major muscle (an elevator of the ribs), and move upward in inspiration; and since the last six ribs present concave lower borders, give origin to the Diaphragm (a depressor of the ribs), and move downward in inspiration, no objection can be urged to the use of the term "*upper ribs*" to designate the former group, or to the use of the term "*lower ribs*" to designate the latter. For clinical purposes this classification is all that is needed, and has at least the advantage of simplicity. At the same time it is convenient to retain the terms "true, false, and floating ribs," since they are separated from one another by trenchant and easily remembered characters.

The ribs increase in size from the first to the eighth, and decrease from the ninth to the twelfth. Each rib presents for examination a head, or vertebral extremity, a sternal or anterior extremity, a neck, a tubercle, a body, and an upper and a lower border. In addition, the majority of the ribs present an angle, and three articular facets; of the latter, two belong to the head, and one to the tubercle.

The *head* or *vertebral extremity* is furnished with an articular surface, which, in all the ribs excepting the first, eleventh, and twelfth, yields two facets, the lower of which is the larger. A faint ridge (*crista capituli*) separates the facets for the attachment of the interarticular ligament. The head of each of the ribs, as above limited, articulates with a pair of vertebræ as follows: first, with the body of the vertebra corresponding in number to that of the rib; and, secondly, with the body of the vertebra directly above it. The portion of the bone lying between the head and the tubercle is called the *neck*.—The neck is best developed

[1] Diseases of the Throat, 277.

[1] Medical Anatomy, 1869, col. 62.

[2] L. c., 1869, col. 62.

in the upper ribs, and is almost entirely absent in the eleventh and the twelfth. It is a flattened or irregularly prismatic process; smooth within and roughened without for the attachment of the middle costo-transverse ligament. Its upper border is slightly elevated from the seventh to the tenth ribs to give attachment to the anterior costo-transverse ligament.—The *tubercle* lies at the junction of the neck with the shaft. An *articular facet* is here seen which looks downward and outward to articulate with the transverse process of the vertebra to which the rib belongs. To the outer side and above the facet is a rough eminence for attachment of the posterior costo-transverse ligament.—The *body* of the rib is that portion lying between the tubercle and the sternal extremity. It is smooth on its inner side, but roughened on its outer, for the attachments of muscles, chief among which are slips of origin of the Serratus Magnus. Its *upper border* is thin and compressed in the first, the second, the eleventh, and the twelfth ribs, but rounded for the remaining ones. In all, the upper border presents a roughened surface for the attachment of the Intercostal muscles. The *lower border* is grooved (see Intercostal Muscles) from about the angle to near the anterior extremity for the reception of the intercostal vessels and nerve. The upper edge of the *groove* gives origin to the Internal Intercostal muscle; the lower edge, which is slightly produced, gives origin to the External Intercostal muscle.—The *angle* is that portion of the rib in connection with the insertion of slips of the Sacro-Lumbalis muscle. It determines the limits of the medio-dorsal aspect of the thorax, *i.e.*, the space limited by points at which the ribs are abruptly directed forward. Almost absent on the first rib, the angle is slightly developed on the second, third, and fourth ribs; it increases in size until the eleventh is attained, beyond which it again decreases, and is entirely absent on the twelfth.—The *sternal* extremity of the rib is broader than the body, excepting from the ninth to the twelfth ribs, where it is smaller. The borders of this extremity are obtuse; the terminal surface is concave for the corresponding costal cartilage. The sternal end of the costal curve has been called, on perhaps insufficient grounds, *the anterior angle.*[1]

The Twist of the Rib.—The general form of the rib, while arched outward and forward, is curved downward, so that the sternal end is lower than the vertebral. As the ribs increase in length from above downward the tendency of the inner surface *near the vertebral end* to be inclined downward and inward is decided. In common with this the surface about the *middle of the body* of the bone is inclined downward and outward. The gradual change from one to the other inclination, conjoined with the tendency constantly present of the sternal end of the bone to assume a position below the plane of the vertebra to which it belongs—a tendency best seen in the ribs from the fifth to the ninth—gives a spiral shape to the bone which has been described as the *twist of the rib.* This shape is more evident in the isolated bone than in articulation.

Peculiar Ribs.—The foregoing description is applicable to a rib situated between the third and the tenth. It would not apply to the others, for the following considerations:—

The *first rib* is placed more horizontally than the other ribs, and yields a shorter curve. Its outer surface looks upward, and its inner surface looks downward. The head bears a single articular facet, and articulates with the first dorsal vertebra alone. Its upper surface is marked by a faint ridge which terminates in a tubercle upon its upper border for the insertion of the Scalenus Anticus muscle. In front of this is a broad shallow *groove* for the subclavian vein; behind it lies a second deeper *groove* for the subclavian artery. To the outer side of the groove for the subclavian artery is a rough surface for insertion of the Scalenus Medius muscle. The tubercle of the first rib is the largest of any of the ribs, and is firmly sup-

[1] Cruveilhier, Anatomy, l. c., Birkett, Trans. Path. Soc. of Lond., 1853, 105.

EXPLANATION OF PLATE XXVI.

Fig. 1. The clavicle, seen from beneath.

Fig. 2. The clavicle, seen from behind. The nutritious foramen lies directly above the letters "Fig. 2."

Fig. 3. The clavicle, seen from in front.

For "STERNO-MASTOID" read "STERNO-CLEIDO-MASTOID."

Fig. 4. The first rib, seen from above.

Fig. 5. The second rib, seen from above.

PLATE XXVI

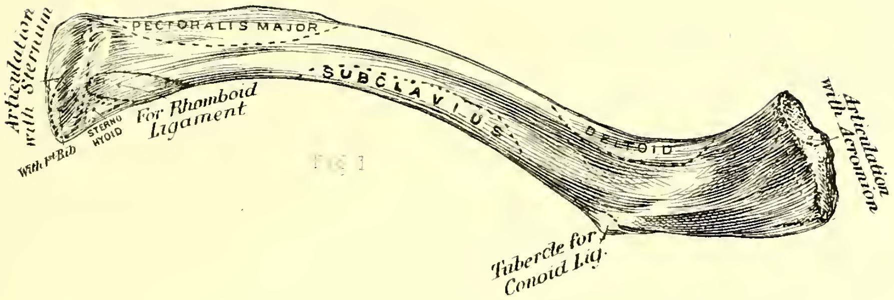


Fig 1

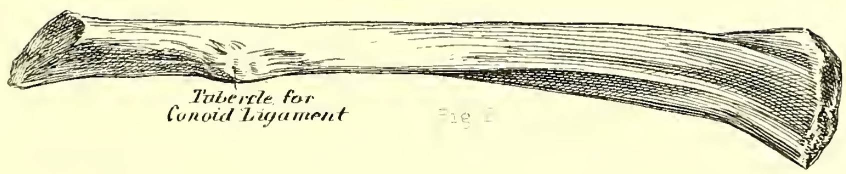


Fig 2

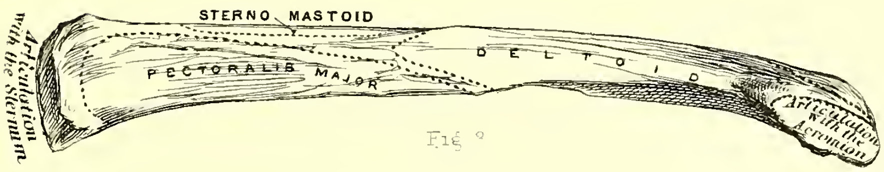


Fig 3

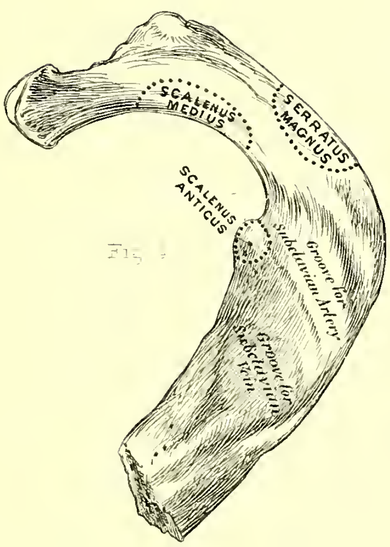


Fig 4

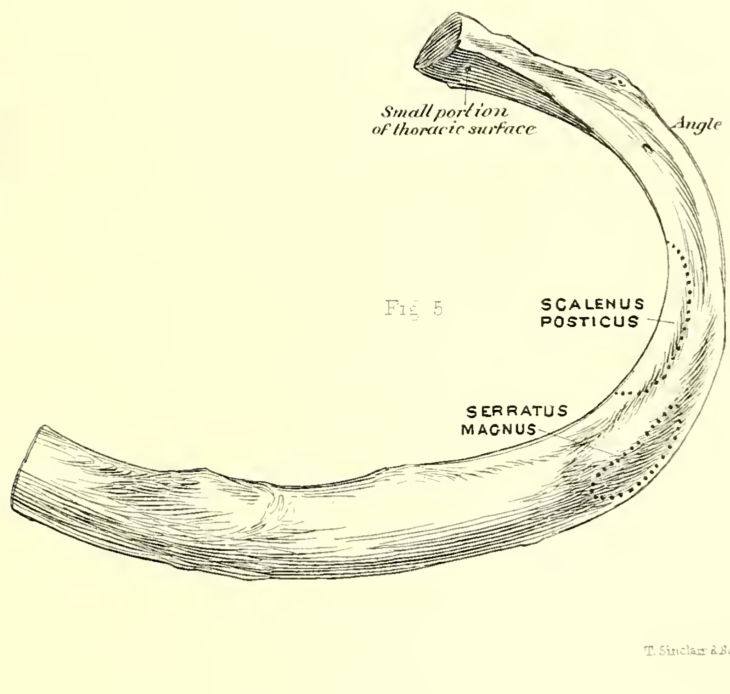


Fig 5

T. Sinclair & Son, lith

ported by the transverse process of the first dorsal vertebra. The angle is almost absent, and no groove exists for the intercostal vessels and nerve. The sternal extremity is thicker than in any of the true ribs.

The *second rib* agrees with the first in being more horizontal than the other ribs. Its head presents a faint interarticular ridge. It is marked upon its outer surface by a large rough surface for attachment of the Serratus Magnus muscle.

The *eleventh* and *twelfth* ribs yield larger curves than do the other ribs. Their inner surfaces opposite the neck are more inclined, while, as already seen, the anterior extremities are narrowed.

In addition to the above characters of the ribs the following may be considered with advantage in identifying isolated ribs or fragments:—

The facet of articulation with the transverse process of the vertebra is in the first rib carried upon the end of a short process, which is directed slightly downward, so that the end of the process is best seen upon the lower surface of the rib. The ribs from the first to the sixth seen in articulation from the interior of the thorax present at the point answering to the neck a vertical surface, and exhibit from the upper borders of the smooth surfaces entering into the pulmonary sinus a slight crest for the anterior costo-transverse ligament. The ribs from the seventh to the twelfth present from within the thorax a slightly inclined surface at about the neck, and each bears a sharp crest at the upper border.

STRUCTURE.—The ribs are cancellous throughout (being least so at the angle), with firm lateral walls.

DEVELOPMENT.—Each rib arises from a single centre of ossification for the body which appears as early as the eighth week, and from two small accessory centres, one appearing in the head and the other in the tubercle. The rib is completed at about the twenty-fifth year.

REMARKS.—Deformity of the rib may be either congenital or acquired. Dr. Robert Adams has recorded[1] an instance of congenital deformity of the first pair of ribs. The left rib was two inches long and straight, and presented a free projecting, somewhat flattened extremity, which was joined to the second rib by a process ascending from the latter. The left subclavian artery ran in front of the distal extremity of the deformed rib as above described, and was supported by the bony elevation of the second rib. The right first rib was shortened and malformed, and supported the right subclavian artery.—A forked rib is one which sends off a process either above or below the main costal axis. It may end in an intercostal space, or, advancing forward, may be joined by an intercostal cartilage.—The sternal ends of the ribs are apt to be deformed in rickets.—Dislocation of the rib is a rare lesion.[1]—The ribs are among the most vascular of the bones, and are hence liable to caries and inflammation.—The angles of some of the ribs are so roughened externally that a careless observer may mistake such appearances for the effects of old fractures. The inner aspect in such specimens is always smooth, and can thus be distinguished from ribs that have been fractured. The last cervical (see p. 114) and the first lumbar vertebra rarely bear rib-like processes. The last-named rib is the more frequent. The twelfth rib may be absent or smaller than usual.—The ribs that are most exposed are those included between the fourth and the tenth, and these therefore suffer most from direct violence. In fracture the bone most frequently gives way at the angle or near the sternal end.

THE COSTAL CARTILAGES.

Attached to the sternal ends of the ribs are twelve cartilages which, from their resemblance to the ribs, have received the names of the *costal cartilages* (fig. 4, Plate XXV.). In the upper ribs these cartilages lie between the sternal ends of the ribs and the side of the sternum; in the lower ribs they either lie between the sternal ends of the ribs and the borders of adjacent ribs, or, as in the last two, they serve as tips simply to their respective bones. The cartilages of the false ribs aid in defining the inferior margin of the thorax anteriorly. The ends of each cartilage are convex, and are secured in corresponding depressions on the ribs and the sternum. The union of the cartilage with the corresponding rib is in all instances without articulation; but the union of the cartilage with the sternum is diarthrodic, excepting that of the first rib.

Respecting the shape of the costal cartilage it may be said that the costal portion of each cartilage is in the line of the sternal end of the rib to which it belongs. In the ribs from the first to the fourth, and in

[1] Dublin Path. Soc. Trans., 1839, quoted in Med.-Chir. Trans., lii. 288.

[1] Buttet, Mém. de Chirurg., v. 1784, 593.

the eleventh and the twelfth, the entire cartilage is thus placed; but in the remaining ribs the costo-axial portion is less than one-half of the entire length of the cartilage. The remaining or sternal portion ascends at an angle to the costal, either to join the sternum or the adjacent cartilages. The degree of ascent in each cartilage bears an exact relation to the downward inclination of the rib to which it belongs. The sternal end is narrowed to a greater or less degree in all the costal cartilages excepting the first.

The movements of the upper costal cartilages are more or less limited, if indeed they are not entirely absent at the region of the first rib. The movements of the lower ribs, on the other hand, are very free; they expand the base of the thorax in inspiration. Hence the costal cartilages may be said to increase the basal measurement of the thorax while aiding the ribs in maintaining the elasticity of the thoracic walls. Owing to ossification of the cartilages, this elasticity diminishes in adult life, especially at the region of the upper ribs. In old age the costal cartilages are almost invariably ossified. In adult life they may be fractured.

THE STERNUM.

The sternum, or the breast bone (fig. 4, Plate XXV.), is a large flat bone placed at the anterior part of the thorax, and is held in position by the ribs. It assumes a slanting position downward and forward, so that its anterior surface looks slightly upward, and its posterior looks downward and backward. Its upper border is thus nearer the vertebral column than the lower, and answers in position to about the level of the second dorsal vertebra. The sternum is from seven to eight inches long, by one-and-a-half to two inches wide, and is six lines thick at its lower part. It is broader above than below, and is marked upon the sides along nearly its entire length by concave depressions for union with the costal cartilages.

The sternum bears a rude resemblance to an ancient Roman sword, and its several portions have been named in consequence the *manubrium* (handle, presternum), the *gladiolus* (body, blade, mesosternum), and the *ensiform process* or *cartilage* (xyphoid cartilage, tip, metasternum). The line of junction between the manubrium and the gladiolus forms a distinct transverse ridge upon both the anterior and the posterior aspect of the bone. The former is often visible in the living subject.

The *manubrium* is the stoutest and thickest portion of the bone. It is broad above, somewhat contracted below. It is a little less than half as long as the gladiolus, and serves for articulation with the first pair of ribs and the clavicles. Its upper margin is thick and rounded, and is transversely concave to form a semilunar depression—the *inter-clavicular notch* (fourchette)—which is covered by the inter-clavicular ligament, and is deepened in life by the median ends of the clavicles. Upon either side of the notch are the articular, saddle-shaped surfaces for the last-named bones. They are directed downward and outward, are concave from without inward, while convex from before backward. The lower margin of the manubrium is nearly flat for articulation with the gladiolus. The sides are marked above by the simple depression for the first costal cartilage, and below by the half facet entering into the costo-sternal articulation of the second rib. The first-named joins the outer border of the clavicular articular surface, and is inclined obliquely downward. The manubrium has the following muscular attachments: the Sterno-Cleido-Mastoideus, the Sterno-Hyoid, and the Sterno-Thyroid muscles; the last two appearing upon the posterior surface.[1]

The *gladiolus* is somewhat egg-shaped, being slightly broader below than above. Its lateral margins are marked by double-faceted depressions for the costal cartilages, in such order that the second rib joins the manubrio-gladiolar junction, and the seventh rib joins the gladiolus and the ensiform cartilage. The remaining costal cartilages are separated by semilunar depressions, which toward the lower end of the bone are nearly if not quite contiguous. The anterior surface is marked by three transverse lines, which indicate the union of the four pieces of which this portion of the sternum originally consists. An opening (sternal foramen) indicating a defect of development between the third and the fourth pieces is occasionally found. The gladiolus gives attachment to the Pectoralis Major in front and to the Triangularis Sterni behind.

The *ensiform process* or *cartilage* is a thin spatula-like process having a variable length of from one-half inch to one-and-a-half inches. It is depressed below the level of the lower extremity of the gladiolus, so that when the integument covering it is in position a pit is demonstrable, consisting of the so-called *scrobiculus cordis*, or pit of the stomach. It is embraced by the linea alba. The anterior surface gives attachment to the costo-xyphoid ligaments; the posterior surface to

[1] By a mechanical error the attachment of the last-named muscle is represented in the figure upon the *anterior* surface.

the Diaphragm and the Triangularis Sterni muscle. Its borders are attached to the aponeuroses of the abdominal muscles.—The ensiform cartilage is the most variable portion of the sternum. Instead of being spatula-like, it may be rounded, or forked. It may be deflected from the median line, or even turned directly backward. It is sometimes furnished with foramina.—According to Sibson,[1] the basal half inch of the ensiform cartilage receives at its side the fibres of the Diaphragm that appear in the notch between the cartilage and the seventh rib. The pleura lines these fibres posteriorly.

Structure.—The sternum is composed of small, very vascular cancelli, inclosed between the anterior and the posterior walls.

Articulations.—The sternum articulates with the clavicles and the costal cartilages from the first to the seventh inclusive.

Development.—The first centre of development appears in the manubrium at the fifth or the sixth month of fœtal life, and is usually single. The upper portion of the gladiolus forms a distinct segment, and arises from a single centre at the seventh month. For the remaining three segments the centres ordinarily appear in pairs within the first year. The ensiform process does not ossify until the sixth year. The gladiolus is complete about the twenty-fifth year.

The sternum rarely or never completely ossifies, except in old age. Thus the manubrium and the gladiolus are united by cartilage. The remaining portions, however, coalesce. The junction between the ensiform process and the gladiolus is perfected at about middle life, and the different portions of the gladiolus from the twentieth to the fortieth year.

Congenital defects of the sternum ordinarily have their origin in the failure of the bi-lateral centres of the gladiolus to unite in whole or in part.

Remarks.—The sternum from its cancellated structure is a relatively vascular bone, and responds to diseased action very much after the manner of spongy bone elsewhere. It is, as a consequence, a frequent site of caries, particularly in the negro; it is the locality to which the pains of constitutional syphilis are commonly referred. It yields readily to pressure, as from an aortic aneurism, and can be perforated by sharp cutting instruments.—The sternum is subject to considerable variation in form. Thus, the two clavicular facets may not be of exactly the same height; a supplemental pair of costal cartilages are rarely appended to the base of the ensiform cartilage. As already mentioned, one or more rounded openings, resulting from defective ossification, are occasionally seen in the gladiolus. Instances have been collected of punctured wounds received through such spaces—while mediastinal abscesses have opened through them.[1] The transverse line between the manubrium and the gladiolus is often so pronounced as to resemble an old fracture.—The ensiform cartilage, when deformed either by growth or by vicious position after injury, may by its backward pressure excite irritation.[2]

The sternum is covered by fibrous tissue on all its surfaces, recalling in both position and use the periosteum. The anterior fibrous layer is composed of fibres which cross one another in every direction, and which are closely adherent to the surface of the bone and the cartilages. The posterior layer is composed chiefly of longitudinal bands of white fibrous tissue, which are but slightly adherent to the bones and the costo-sternal articulations.[3] It is much stouter than the anterior, and in dislocation of the parts of the sternum on each other may be stripped from the bone. In the now nearly obsolete operation of trephining the sternum, this membrane is an obstacle to the easy removal of the circle of bone.[4]

The joint between the manubrium and the gladiolus, according to Maisonneuve,[5] is either fibrous or diarthrodial; it is fibrous in character in about twenty-five per cent. of cases, and diarthrodial in seventy-five per cent. The joint is rarely obliterated.[6]

When the diarthrodial joint exists, the layer of fibro-cartilage belonging to the gladiolus is continued on each side without interruption to the facet destined for the cartilage of the second rib, whilst the layer belonging to the manubrium adheres to the upper border of the second costal cartilage. The latter slip is separated as a rule from the manubrium by a synovial membrane. It is absent in about three per cent. of specimens. It follows upon this arrangement, according to Maisonneuve, that the second rib is much

[1] Medical Anatomy, l. c.

[1] Cruveilhier, Anatomy of the Human Body (Am. ed.), 1844, 65.

[2] Blandin, Topograph. Anat., Doane edition, 1834, 163.

[3] Jno. H. Brinton, Am. Journ. Med. Sci., 1867, 39.

[4] Hyrtl, Topograph. Anat., i. 548.

[5] Archives Générales de Médecine, iii. Série, xiv. 1842.

[6] Brinton, Jno. H., l. c. W. Rivington, Med.-Chir. Trans., lvii., 1874, 112, found one-half per cent. to be fibrous, one-third to be diarthrodial, and the remainder to be intermediate between the two already named, or obliterated by ossification. The diarthrodial form is more commonly met with in males than in females.

more strongly attached to the manubrium than to the gladiolus. This explains the fact that in luxation of the manubrium or the gladiolus the latter always abandons the cartilage of the second rib, while the former remains constantly united to it.

Episternal bones in the form of small sub-rounded nodules attached to the upper margin of the manubrium are rarely seen.[1] They are situated on either side of the interclavicular notch, and are homologous with the larger bones of the same name in the monotreme mammals. In man they are of use in giving increased support to the thoracic ends of the clavicles.—A tumor of the sternum simulating aneurism has been described by Ollivier.[2]—The projection on the anterior surface of the bone at the union between the manubrium and the gladiolus, when pronounced, retains the mediæval name of the *angulus Ludovici.* It indicates recession of the first pair of ribs, and is often found associated with other tubercular tendencies.—The skin over the sternum retracts to a great degree after incision. More than usual care should as a result be taken in making incisions in this region of the body.[3]—For differences in the measurements of the sternum in the male and the female, see page 102.

The sternum being suspended to the costal cartilages follows the movements of respiration. The lower portion is pushed forward in inspiration, while the bone is raised. It follows that the relations of the sternum to the fixed parts will vary. Subject to slight modification it may be said that the upper margin of the sternum answers to the second dorsal vertebra or to the second dorsal spine; the junction between the manubrium and the gladiolus is opposite the third dorsal spine, and the junction between the gladiolus and the ensiform cartilage is opposite the sixth dorsal spine.—The median line of the sternum is not parallel to the median line of the abdomen, but forms with it an angle at the ensiform cartilage which is directed to the right.[4]

THE THORAX.

The thorax is that portion of the skeleton formed by the articulation of the ribs, the costal cartilages, the sternum, and the dorsal vertebræ. In the undissected subject, the thorax is equivalent to the chest of common language, and includes the Intercostal muscles at the sides and the Diaphragm at the base. The thorax is the great respiratory cavity of the body as well as the chamber for protection to the heart, and in some degree to the great vessels, the œsophagus, and in the fœtus to the thymus gland.

The figure of the thorax is conical, compressed from before backward, and presents oblique upper and lower surfaces. It is grooved longitudinally on either side of the spinous processes at the back; it is flat, and inclined slightly forward in front, and is convex at the sides. Within, the thorax presents a general concave surface except posteriorly, where the bodies of the dorsal vertebræ project forward. Its greatest circumference is about its middle or a little below, where its average measurement is twenty-five inches.

The thorax presents for examination the dorsal vertebræ, the ribs, the costal cartilages, and the sternum (which have been described), as well as the superior and inferior apertures, and the intercostal spaces.

The *superior thoracic aperture* is bounded behind by the body of the first or second dorsal vertebra, at the sides by the first pair of ribs and the costal cartilages, and in front by the upper border of the sternum. It is kidney-shaped, its antero-posterior (sagittal) diameter being a little over two inches, while its transverse (frontal) is nearly five. It contains the œsophagus, the trachea, the apices of the lungs, the pleuræ, the subclavian arteries and veins, the carotid arteries, the internal jugular veins, the termination of the thoracic ducts, and the lymphatics and nerves.

The *inferior thoracic aperture* is of an irregular figure, owing to the absence of union of the eleventh and twelfth ribs with the other ribs or sternum. It is less fixed in its outline as compared to the superior aperture, in consequence of the larger proportion of cartilage intervening between the ends of the ribs and the sternum. It is closed by the Diaphragm in the subject, yet permitting the passage of the inferior vena cava, the aorta, the œsophagus, the main thoracic duct, and the sympathetic nerves.

The *intercostal spaces* are narrower behind than in front, and with the upper ribs they are widest at about the junction of the ribs and the costal cartilages. The spaces between the false ribs naturally lessen in width as the cartilages converge towards each other. The spaces are occupied in the subject by the Intercostal muscles, the arteries, and the nerves. The first and the second are larger than the others, but on the whole the spaces tend to increase from above downward—that between the sixth and the seventh rib being the widest at the sternal margin.

[1] Luschka, Zeit. für wissenschaft. Zool., 1852, 36; T. W. King, Guy's Hosp. Rep. v. 1840, 227.

[2] Comptes Rendus, 1868, 221.

[3] Richet, Anat. Medico-Chirurg., 545.

[4] Sibson, l. c., quoted from J. W. Conradi. Upon the Position and Size of the Thoracic Organs. Giessen, 1848, 3.

In addition to the terms *superior* and *inferior* apertures the terms *apex* and *base* are in use by clinical writers. The *apex* is vaguely defined, and may be said to answer to the upper portion of the cone-like figure of the thorax. It has also been said to accommodate the apical portions of the lungs. In consequence of the fact that the apex of the lung is not confined to the thorax, the latter determination can have but slight significance. The *base* of the thorax is of much more value. It is defined by Sibson[1] in the following language: The base extends like a girdle across the lower ribs from the end of the eighth rib in front to that of the twelfth behind, and answers to the circuit at which the pleura is reflected from the Diaphragm upon the ribs and the Intercostal muscles, and down to which the lungs can descend during the deepest possible inspiration in the living, and when distended to the full in the dead. In such a position as the one last named, the base of the thorax is almost a straight line, crossing the extremities of the four lower ribs in an oblique direction from before backward and downward.

Remarks.—The shape of the thorax and the proportion it bears to the rest of the body are subject to much variation. In the infant the thorax is relatively smaller than in the adult. In the female the upper portion of the thorax is less compressed from before backward, and is more capacious than in the male; the superior thoracic aperture is larger, and the motions between the upper ribs and the sternum and the vertebræ are more conspicuous. From these circumstances the respiratory movement in the thorax of the female is decided as compared with that of the male, and has from this circumstance been called *thoracic*. In the male the lower ribs and the abdominal walls are seen moving more freely than the upper; so that with him respiration is said to be *abdominal*.

The thorax is of necessity modified in shape by the condition of its contents. When the lungs are expanding as in *inspiration*, the ribs from the first to the sixth (upper ribs) are raised toward one another so as to narrow the intercostal spaces, the sternum ascends, and the anterior thoracic aperture assumes a nearly horizontal position. At the same time the ribs from the seventh to the twelfth (lower ribs) are depressed so as to widen their intercostal spaces, and the inferior thoracic aperture is increased in size; the twelfth rib remaining nearly stationary. When the lungs are contracted as in *expiration* the reverse of the movement described takes place. The upper ribs are far apart, and the remaining ribs are elevated and approximated at the side of the chest.

In emphysema the characteristics of inspiration with bulging intercostal spaces, and in phthisis those of expiration with depressed intercostal spaces, are maintained and exaggerated. In chronic asthma a peculiar cylindroid form of thorax is detected, which has received the name of the "barrel chest."

The respiratory movements may, indeed, be said to determine the shape of the thorax. Even in the artificial skeleton the disposition of the ribs from the first to the sixth to present convex lower borders, and that of the ribs from the sixth to the tenth to present concave lower borders, is evident. By this character the ribs that *ascend* in respiration can be distinguished from those ribs that *descend* in respiration, the latter being least marked in the case of the eleventh and the twelfth.

A careful inspection of the interior of the thorax in the skeleton is useful. The first and second ribs directly overlie the thoracic chamber, forming its roof; the remaining ribs lie at the sides. It is evident that the first-named ribs will yield a percussion note answering more exactly to the resonance of the entire thoracic space than will one elicited from the ribs either at the sides or at the back.—The projection of the line of bodies of the dorsal vertebræ forward, and the curvature of the ribs, give to the transverse sections of the thorax a kidney-shape. The vertebral column answers to the hilus of this figure, and the deep symmetrical curves on either side to the surface above and below the hilus. These deep curves lying between the sides of the vertebræ and the sides of the thorax correspond to the posterior thoracic surface, and may receive the name of the *pulmonary sinuses*, since they lodge the convex posterior surfaces of the lungs.

The form of the thorax is in great measure concealed in the undissected subject. The clavicles and the muscles attached to it obscure the outline of the first and second ribs. The scapula, when the arms are at rest, covers in and conceals the dorsal surface from the second to the eighth or ninth ribs. In front, at the back, and at the sides, muscular masses protect the parietes as with pads or cushions, and remove many of the costal surfaces from observation and the touch. It is well to remember that even in very muscular or fleshy individuals the following points can always be made out, no mention of the sternum and the beginnings of the costal cartilages being

[1] Medical Anatomy, col. 37.

thought necessary. The anterior border of the Pectoralis Major answers to the line of the fifth rib. The first visible digitation of the Serratus Magnus is attached to the sixth rib; the second digitation to the seventh rib. The hand of the subject or model being placed upon the head exposes the *axilla*, which is defined by the Pectoralis Major and Pectoralis Minor in front, and by the Latissimus Dorsi, Teres Major, and Subscapular muscles behind: the Serratus Magnus forms the *floor of the axilla*, which corresponds to the space from the second to the fifth ribs. In this space the lung-sounds can be heard with greater ease than at any other part of the chest, and they should here be sought for in all careful examinations of the conditions of the apex.—Richet[1] states that abscess of the axilla can cause irritation and thickening of the adjacent pleura by direct transmission through the thoracic parietes. Holden[2] suggests that the lines of the anterior and the posterior walls of the axilla produced down along the sides of the thorax should receive the name of the *axillary lines*.—The *nipple* overlies the fourth intercostal space, the fourth or even the fifth rib. It varies in position according to the state of the thorax. In emphysema the nipple, if it remains stationary while the upper ribs ascend, would answer to the fifth, and in extreme cases to the eighth. On the other hand, in shallow chests with depressed ribs, as seen in phthisis, the nipple may answer to the fourth.—The costal cartilage of the seventh rib lies at the junction of the base of the ensiform cartilage with the gladiolus. This position can be readily determined on the subject through the integument, and an easy method is thus presented of fixing the anterior border of the inferior thoracic aperture.—The positions of the floating ribs can always be recognized by the touch.

If a tape-line whose initial end lies over the sternal end of the first rib is drawn transversely across the front of the thorax, and thence to the spines of the vertebral column, the terminal end will be found to rest upon the vertebral end of the fifth rib. On such a basis Luschka has elaborated, as in the following table, a series of lines for all the ribs:—

Table of Relations between the Anterior and Posterior Surfaces of the Thorax.

STERNAL END.	POSTERIOR EQUIVALENT.
The Sternal end of the first rib is on the same line as the	Vertebral end of the fifth rib
" " " second " " "	" " " seventh "
" " " third " " "	" " " eighth "
" " " fourth " " "	" " " ninth "
" " " fifth " " "	" " " tenth "
" " " sixth " " "	Middle of the vertebral and of the space between the tenth and eleventh ribs
" " " seventh " " "	Vertebral end of the eleventh rib
" " " eighth " " "	Beginning of the transverse process of the first lumbar vertebra
" " " ninth " " "	Near the body of the second lumbar vertebra
" " " tenth " " "	Near the body of the third "
" " " eleventh " " "	" " " "
" " " twelfth " " "	" " " "

From what has been said in connection with the subject of the respiratory movements of the thorax, it is evident that some variation will exist in these lines. In the thorax prepared in the form of inspiration the lines for the upper six ribs would lie somewhat above the level of the vertebral equivalents given in the table; in like manner, in the thorax prepared in the form of expiration, the lines for the lower ribs would be a little below.

For the relations between the liver, the stomach, and the spleen and the base of the thorax, see the account of those organs.

[1] Anat. Medico-Chirurg., 877.

[2] Landmarks, 68.

THE BONES OF THE UPPER EXTREMITY.

The bones of the upper extremity are those of the shoulder, the arm, the forearm, and the hand; they include the clavicle, the scapula, the humerus, the ulna, the radius, the carpal bones, the metacarpal bones, and the phalanges.

THE CLAVICLE.

The clavicle, or the collar bone (figs. 1, 2, 3, Plate XXVI.), is the medium by which the superior extremity is connected to the trunk. It is placed superficially, so that its superior and anterior surfaces can

be defined in the undissected subject between the thorax and the scapula, receiving above the insertions of muscles descending from the neck, and affording surfaces of origin to those ascending from the sides of the chest. The clavicle is inclined from the sternum and the first costal cartilage (see fig. 3, Plate XXXVII.) a little diagonally outward and backward, and at the thoracic two-thirds is cylindroid, while at the scapular third it is flat, thin, and irregular.

Seen from above, the bone is shaped like an italic letter *f*, placed horizontally; the initial right-hand curve is the *thoracic end*, the main stroke of the letter is the cylindrical *shaft* or *body;* the terminal curve is the *scapular* or *acromial end.* At the junction of the thoracic end with the shaft, on the under surface, the *impression for the costo-clavicular ligament* is seen; at the junction of the body with the scapular portion lies the *conoid tubercle.*

The *body* of the clavicle extends from the outer margin of the impression for the costo-clavicular ligament to the conoid tubercle. It is slightly narrowed from before backward to give origin to the clavicular fibres of the Pectoralis Major muscle; it is convex anteriorly and concave posteriorly. The curves of the body are continuous with those of the thoracic, but are abruptly separated from those of the scapular end. The orifice of a *nutritious canal* directed laterally is seen on the posterior surface. Stretching across the under surface of the body from the conoid tubercle in front to the posterior and inferior border is an oblique line which limits the surface of origin of the Pectoralis Major muscle inferiorly. Near the oblique line is the narrow *depression* for the Subclavian muscle.

The *thoracic end* of the clavicle is nearly square, the anterior and the posterior surfaces remaining as in the body, while the superior and inferior are broader. The superior smooth surface receives at its posterior border the insertion of the clavicular portion of the Sterno-Cleido-Mastoideus muscle. The anterior surface presents a ridge for the fibres of the Pectoralis Major, while the inferior surface toward its anterior aspect is roughened, as already mentioned, by the impression for the costo-clavicular ligament. The posterior surface is smooth. The *articular surface* is of a triangular or subrounded figure, the broadest portion being directed upward and forward, while the narrowest is downward and backward. The articular surface is depressed in the centre, and all the borders excepting the superior are rounded, and appear more or less upon the sides (fig. 2, Plate XXVI.). The antero-inferior lateral facet, as contrasted with the others, is limited abruptly by a sharply projecting lip. The lower end is the least liable of any part of the thoracic portion to be invaded by diseased action. In the macerated bone the articular surface is roughened and irregular, but in the subject it is smooth and saddle-shaped.

The *scapular* or *acromial* end of the clavicle extends from the conoid tubercle to the end of the bone. It is broad and flat, thicker behind than in front, sharply concave anteriorly and abruptly convex posteriorly. The anterior edge of the upper surface gives origin to the Deltoid muscle by a deep lunated impression. Near the posterior border a faint ridge indicates the insertion of the clavicular fibres of the Trapezius. The under surface from the conoid tubercle forward and outward is irregularly ridged (oblique line) for the attachment of the coraco-clavicular ligament. The oval or rounded scapular (acromial) articular surface does not occupy the entire end; it joins the anterior edge of the bone, and looks obliquely downward and outward.

Structure.—The clavicle resembles a long bone in presenting a shaft with walls and spongy extremities. The shaft or body is in great part occupied by a number of lamellæ, beginning and continuous with the thin anterior wall, and extending across the body near to the enormously thick posterior wall. The latter is thicker in the middle than towards the ends of the body, and is gradually lost within the thoracic and the scapular ends. At the junction of the body with the scapular end, the anterior is of equal thickness with the posterior wall, and the interior of the bone is filled with coarse, stout laminæ. It is probable that the disposition of the parts last named explains the great relative frequency of fracture of the clavicle at the junction of the outer with the middle third of the bone as compared with fracture at any other portion. In the thoracic third the cancelli are small, and give increased compactness to the bone at this part. The uppermost cancelli, being here the weakest, are often exposed and disintegrated in cabinet specimens. In the scapular end the most compact tissue lies anteriorly in the line of the facet of articulation; posteriorly the cancelli resemble in structure and behavior the upper portion of the thoracic end already described.

Development.—The clavicle arises from cartilage[1] by two centres of development: one for the main

[1] The bone is generally described as arising from fibrous tissue. Gegenbaur (*infra*) is the authority for the contrary statement.

portion of the bone which appears about the sixth week, and one for the sternal end (pre-coracoid of Kitchen Parker) which appears after the manner of an epiphysis at about the eighteenth year. The epiphysis unites with the shaft at the twenty-fifth year.

The clavicle is thought to be homologous with an intermuscular space or septum (such as the linea transversa of the Rectus Abdominalis) which lies between the Trapezius and the Sterno-Cleido-Mastoid muscles on the one hand, and the Deltoid on the other. In animals without a clavicle, the Trapezius and the Deltoid muscles are continuous, as in the seal and the carnivora generally. In the bear a transverse fibrous inscription alone separates the Deltoid from the cranial fibres of the Trapezius. In the cat, the raccoon, and allied animals a small movable bone without osseous attachment of any kind intervenes between the two muscles.

Remarks.—The clavicle is exceedingly variable in form. In muscular individuals the curves are pronounced, the thoracic articular surface is produced downward, and the facet answering to the upper surface of the first rib is large.—The impression of the claviculo-costal ligament is either on the level of the bone or raised slightly from it. This impression is sufficiently deep in the bone just prior to the union of the median epiphysis to lead observers to mistake it for an effect of diseased action.—The lower border of the impression for the Deltoid sometimes projects as a ragged spine; the posterior border of the acromial end is rarely produced to the level of the plane of the facet, thereby greatly increasing the width of the bone at that place.—In the female the clavicle is straighter than in the male, and the muscular and ligamentous impressions are but faintly marked. The ridge for the coraco-clavicular ligament is sometimes lumpish.—The clavicle occasionally exhibits a foramen at the upper border of the body for the transit of the supra-clavicular nerve.—E. H. Bennett[1] records four examples of variation in the scapular end of the left clavicle, consisting in the extension of the posterior border of the bone to or beyond the level of the plane of the facet, and in the exhibition of a secondary facet which articulates with the spine of the scapula by a diarthrodial joint. In two of the instances the scapula at the acromion was deformed. The region of the scapular facet may exhibit in connection with the last-named variation the results of mal-nutrition, inflammation and erosion, as occurred in two bones that have come under the writer's notice. In such clavicles the enlarged, thickened, and deformed parts are irregular in form, and bear a strong resemblance to formations of old callus, and may be thus mistaken for the effects of fracture. It is well to observe that these appearances are not seen *crossing* the bone, but are confined to the facet and the parts extending thence to the anterior margin of the scapular end.—For variations in the lengths of the clavicles, see p. 102.—C. Gegenbaur[1] describes from the living subject four cases of symmetrical absence of the acromial end of the clavicle, occurring in a mother and her three children. In each case a conspicuous depression existed between the shoulder and the front of the chest, at the bottom of which the subclavian artery could be felt beating. *The motions of the scapula appeared to be unimpaired.*

The motions of the clavicles are determined by the movements of the chest and of the superior extremity. Since the union between the clavicle and the scapula is nearly fixed, that between the clavicle and the sternum and the first rib permits of free motion, and causes the thoracic end of the bone to act as a fulcrum to the scapula, and through the latter to the entire upper extremity. The attachment of the clavicle to the first rib by the antero-inferior lateral facet serves, according to G. Hermann Meyer,[2] to transfer the weight of the superior extremity (as instanced in carrying a heavy body on the shoulder or in the hand) from the arm and the clavicle to the trunk—the vertebral column eventually bearing such strain as is diffused to it through the manubrium and the first pair of ribs.

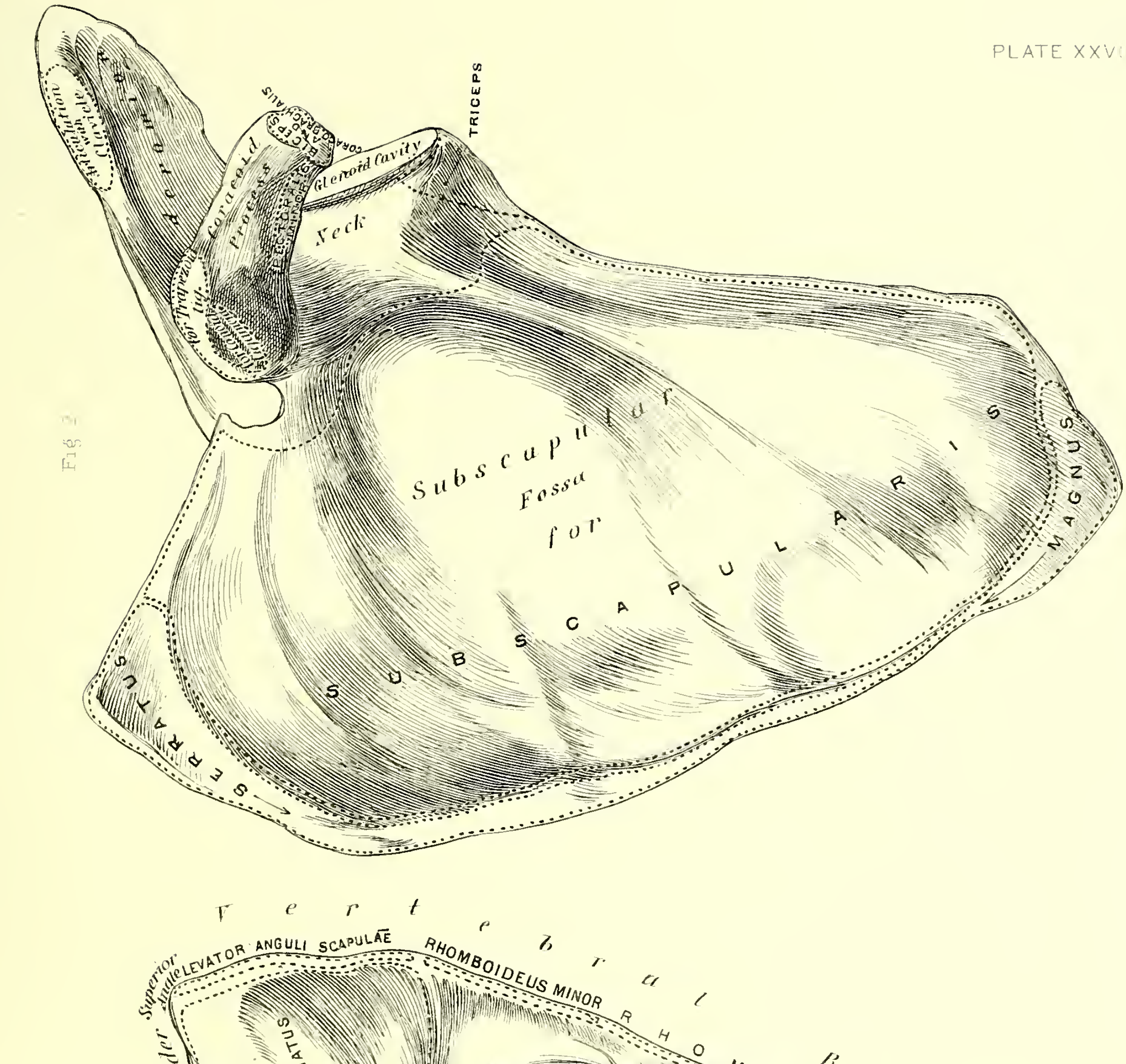
The bone when in the position of rest is on the same level as the spine of the scapula. In inspiration it moves forward an inch.

The clavicle exerts marked influence over the appearance of the neck. As is known, the neck varies greatly in apparent length in different individuals; this difference, evidently, does not depend upon the variations in the measurements of the cervical vertebræ, for these are slight, but upon the position of the clavicles. In individuals of robust habit and large respiratory capacity the clavicles are forced up to a higher plane than in those persons of weak muscular power, whose respiratory capacity is small.—In the corpulent, the subjects of organic heart disease or of

[1] Dublin Journal of Medecine, lvi. 413, 1873, one instance, fig. with scapula; Ibid. lx. 166, 1875, three instances, one with scapula, figs.

[1] Jenaische Zeitschr., Bd. I. 1866.

[2] Lehrbuch der Anatomie des Menschen, 104.



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emphysema, the clavicles are raised and the neck is shortened; while in the subjects of phthisis they are depressed, the shoulders are sloping, and the neck is lengthened. In the full-chested the clavicles pass almost horizontally outward; in the narrow-chested they incline markedly backward. The last-mentioned position of the clavicles is so invariable that it may be taken into account in examination for the early stages of chronic phthisis.—In a condition which may be taken as an average, the median third of the bone answers to the first rib, which it crosses at an acute angle; the middle third to the first intercostal space, from which it is separated by the branchial plexus and the axillary vessels; and the outer third to the coracoid process and the acromio-clavicular articulation.—Enlargements of the subclavian artery and vein can in certain abnormal states aid in pushing up the clavicle, and together with the other causes already mentioned disturb the normal relation of parts at the base of the neck. Operations for aneurism or for subclavian tumors of any kind are from this cause more difficult than would appear from the study of the comparatively superficial structures met with in the subject. Indeed, so great is the difficulty arising from the depth at which the artery may lie that division of the clavicle has sometimes been resorted to prior to ligation of the subclavian artery at its outer third.—In cases of comminuted fracture the internal jugular vein and the subclavian vein have been punctured or compressed. The compression may involve the subclavian artery, and the pulsation of the radial artery may be suspended. Enlargement in the volume of the bone is liable to create similarly injurious pressure. When this is excessive, the expansion of the chest-wall is so interfered with as to create dyspnœa.[1]—In fracture of the bone at the junction of the thoracic end and the body, the former end is fixed by the costo-clavicular ligaments, while the remaining portion of the bone is depressed by the weight of the superior extremity, and the median end is elevated. In fracture of the body (a result of falling upon an outstretched hand) the median fragment is raised by the Sterno-Cleido-Mastoid muscle, the lateral fragment is depressed, and the free end drawn forward, inward, and backward by the action of the shoulder muscles. In the rare fracture between the two divisions of the coraco-clavicular ligament, no displacement occurs; but in fracture to the outer side of this ligament the lateral fragment is pulled downward by the weight of the superior extremity until it is nearly at a right angle to the rest of the bone, which remains in position.

THE SCAPULA.

The scapula or shoulder-blade (figs. 1, 2, Plate XXVII.; fig. 1, Plate XXVIII.) is the main bone of the shoulder. It belongs to the class of the flat bones, is for the most part thin, and possesses a somewhat triangular form. It is situated at the side and at the back of the thorax, and when at rest corresponds to the distance between the second and the seventh or the eighth ribs. The scapula is a very movable bone, owing to its connection with the trunk by means of the clavicle, and to the numerous powerful muscles inserted into it.

The scapula presents for examination two surfaces, three borders, and three angles. The neck, the glenoid cavity, the coracoid process, the spine, with the acromion, are also described.

The *dorsal surface* (dorsum) is divided at its upper fifth into two unequal portions by the *spine*. That portion above the spine is called the *supra-spinous fossa*, and that below the spine the *infra-spinous fossa*. The supra-spinous fossa is concave, and broader toward the vertebral than the axillary border. It gives origin to the Supra-Spinatus muscle.—The infra-spinous fossa is, for the most part, convex for the origin of the Infra-Spinatus muscle, but exhibits a longitudinal depression toward the robust axillary border. Below and to the axillary side of the Infra-Spinatus impression lies the narrow surface of origin of the Teres Minor muscle. Crossing the axillary limit of the fossa at its upper third is a transverse *groove* for the dorsal scapular artery. At the inferior narrow portion of the infra-spinous fossa, below the surface for the last-mentioned muscle, is a smooth triangular space for the origin of the Teres Major muscle. This is limited above by an oblique line separating it from the impression for the Teres Minor. Above the axillary limit of the Teres Major impression is seen the small surface of origin of the Subscapularis muscle, which is occasionally present.

The *under surface* (venter) extends the entire length of the bone. It is concave, and at its upper fifth, viz. at the point corresponding in position to the spine of the scapula, it presents a somewhat pronounced depression, which has received the name of the *subscapular angle*. Below this depression, the subscapular fossa is marked toward the vertebral border by three

[1] John Britton, British Med. Journ. 1870, 519.

or four faint ridges, which serve as points of attachment for the inter-muscular septæ of the Subscapular muscle. Along the vertebral border itself is a rough line for the insertion of the Serratus Magnus.

The *borders* (costæ) of the scapula are the upper, the vertebral, and the axillary.

The *upper border* is thin, and it extends between the superior angle and the *supra-scapular notch*, which transmits the supra-scapular nerve and vein. To the vertebral side of the notch is attached the Omo-Hyoid muscle.

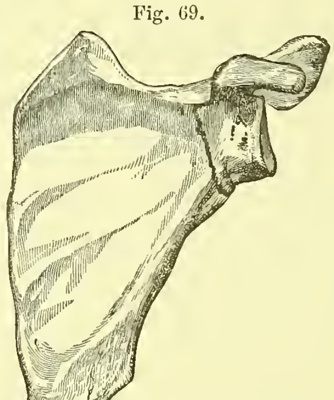
The *vertebral border*, (median[1] inner, internal, posterior,) or *base*, is somewhat thicker than the upper, and is divided by the spine into two portions. Holding the bone in its natural position, so that the dorsal surface remains in full view, the portion of the vertebral border *above* the spine inclines upward and forward; the portion *below* the spine inclines downward and forward. The supra-spinous border receives the insertions of the Levator Anguli Scapulæ and of the Rhomboideus Minor muscles, besides yielding some fibres of origin of the Supra-Spinatus muscle. The infra-spinous border receives the insertion of the Rhomboideus Major muscle.

The *axillary border* (lateral, external, outer, anterior) extends from the glenoid cavity to the inferior angle, and is remarkably thick as compared to the other borders. It is more compressed below than above, where its sides are lost on the neck. Directly beneath the glenoid cavity, with a slight inclination to the ventral surface, is the rough *impression* (infra-glenoid tubercle) for the origin of the long head of the Triceps muscle. Extending thence downward along the greater portion of the border is a *ridge*, which serves to separate the impressions for the Infra-Spinatus and the Subscapular muscles. The axillary border between the termination of the ridge and the angle is occupied by a thin broad spine of varying size, which is continuous with the surface on the dorsum for the Teres Major muscle.

The angles of the scapula are the superior, the inferior, and the glenoid (external). The *superior* is defined by the junction of the upper and the vertebral borders; the *inferior* by the junction of the vertebral and the axillary borders. In examinations of the living subject, the inferior angle is from its prominence often briefly called the *scapular angle*. On the dorsum the last-named part of the bone gives origin to a slip of the Latissimus Dorsi muscle. The *glenoid* angle (external) is represented by the position of the glenoid cavity, and, while essential to the figure of the scapula, is less exact than the other angles. Its description is included in the account of the neck.

The *neck*, unlike the part so named in other bones, is the most important division of the scapula when viewed from a mechanical point. It constitutes that massive portion of the bone which is defined on the axillary side by the swollen edge of the glenoid cavity, and on the vertebral by the base of the spine. A line continued from the last-named point downward to the venter would intersect the axillary border at the impression of the scapular head of the Triceps muscle, as a line continued from the same point upward would intersect the base of the coracoid process. On the venter itself no lines defining the neck exist. A portion of the neck is, therefore, continuous below the spine with the infra-spinous fossa, and above the spine with the supra-spinous fossa. The neck, as above defined, is spoken of by some authors as the *surgical neck* (Fig. 69); the *anatomical neck*, so called, being restricted to a line passing round the edge of the glenoid cavity.

Fig. 69.



Scapula showing the line of fracture in the Surgical neck. It will be seen that the coracoid process and the glenoid cavity are included in the median fragment.

The *glenoid cavity* (glenoid head) is the surface by which the scapula articulates with the humerus. It is uniformly concave, and is semicircular at its lower, but acuminate at its upper half. Its ventral surface is slightly notched on the level with the base of the coracoid process. Superiorly, the cavity is continuous by an everted surface with the *supra-glenoid tubercle* for the origin of the long head of the Biceps muscle. The rim of the cavity is in connection with the glenoid ligament, which serves to deepen the articular surface during life.

The *coracoid process*, so called from its fancied resemblance to a crow's beak, arises as a stout column

[1] The term "median" is in this instance employed by German writers, since this border is nearer to the median line of the back than the "lateral" (axillary) border is to the median line of the sternum.

PLATE XXVIII

Fig 1

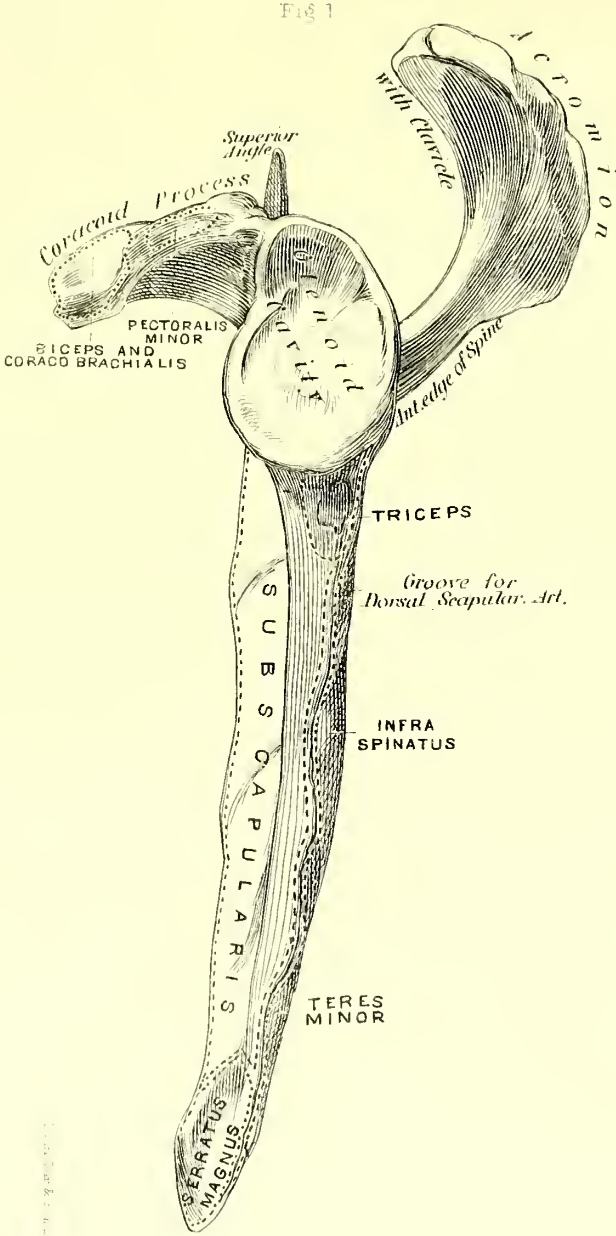


Fig 2

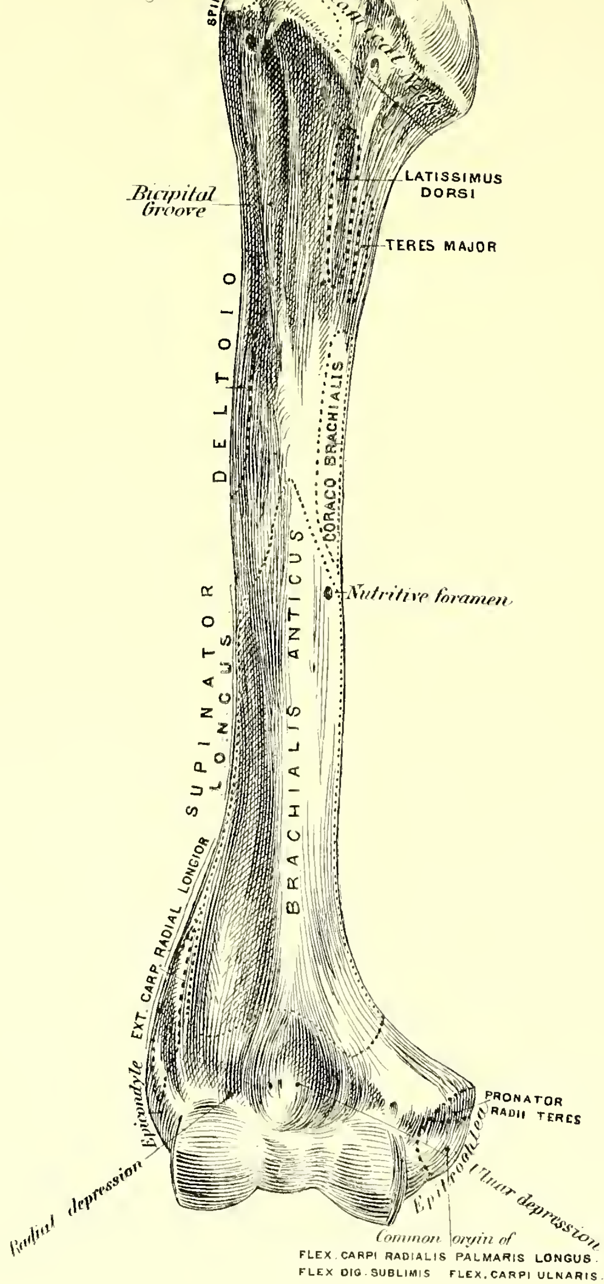
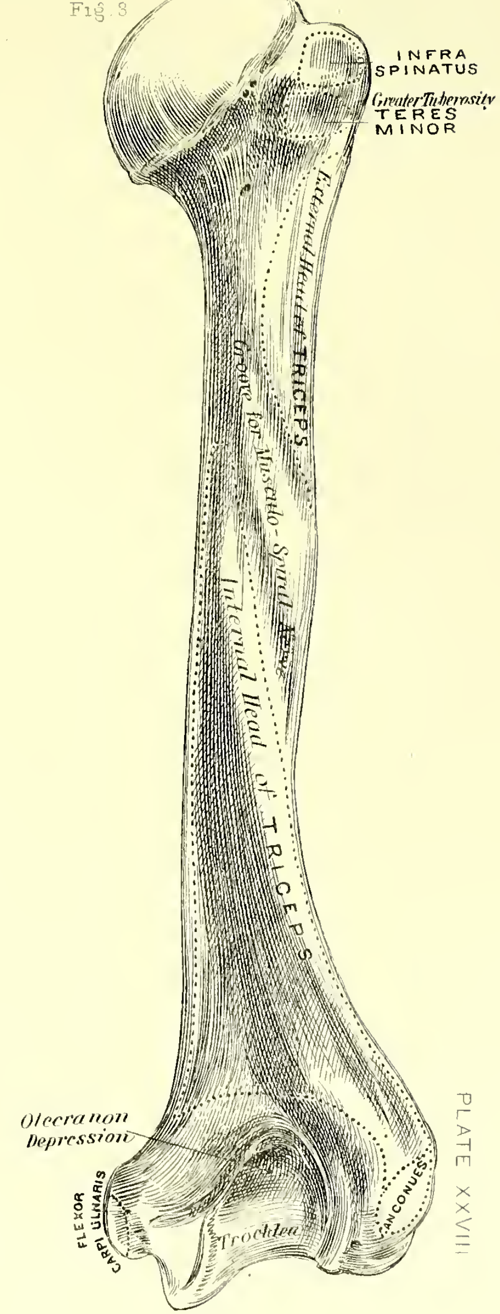


Fig 3



from the entire upper border of the neck. It ascends on the level of the plane of the neck as far as the upper border of the bone, whence it is abruptly deflected downward and forward to end in a narrowed tip. Above, the coracoid process is roughened for the attachment of the acromio-coracoid and the coraco-clavicular ligaments. Exteriorly it yields a point of insertion for the Pectoralis Minor muscle, and of origin for the conjoined head of the Coraco-Brachialis muscle and the short head of the Biceps. The coracoid process acts as a check to the inward movements of the head of the humerus, and unless the process be broken subclavicular dislocation can scarcely occur. The process is homologous with the coracoid bone of batrachians, reptiles, and birds. As seen in these animals, the coracoid bone extends between the sternum and the scapula very much after the manner of the clavicle in the human subject.

The *spine* extends transversely to the plane of the dorsum at its upper third. It is of a triangular form, its face being outward; it begins by a smooth space on a level with the dorsum at the vertebral border of the bone (sometimes called the *root of the spine*), over which the Trapezius muscle glides; thence it inclines slightly upward as it reaches the region of the neck, to terminate abruptly below in a thickened rounded edge; above it widens, and is continuous with the acromion. The upper surface of the spine is concave for the Supra-Spinatus muscle; the lower is inclined upward for the Infra-Spinatus muscle. The Trapezius muscle is attached to the edge of the spine above and to the Deltoid below. The *acromion* is the name given to the tip of the spine as it overlooks the neck of the scapula. The space between the acromion and the neck has received the name of the *great scapular notch.* The acromion is a broad flattened process deflected toward the coracoid process, the plane of whose tip it reaches, and it is curved concentrically to the head of the humerus, which it helps to retain in position. The axillary rounded border of the acromion is continuous with the lower margin of the spine, and gives origin to the middle fibres of the Deltoid muscle; the vertebral border (upper, external) is continuous with the upper margin of the spine, and is furnished with an oval smooth facet for articulation with the clavicle. The inclination of this facet upward and backward accounts for the difficulty of retaining in position the scapular end of the clavicle after its dislocation.

STRUCTURE.—The scapula presents the strongest arrangement of the cancelli at the neck. The lines here radiate from the glenoid cavity toward the vertebral border. They are intersected by a number of laminæ that are more or less concentric with the plane of the articular surface. When it is remembered that no weight is borne by the scapula, the arrangement of cancelli of the neck can have relations with forces exerted from below only—namely, from the humerus. The pressure of the head of the last-named bone against the lower half of the glenoid cavity is very great when the arm is elevated by the Deltoid and the Supra-Spinatus muscles. The object of the cancelli in the scapular neck is to receive and distribute through the scapula the results of such pressure. Spongy tissue is also seen in the coracoid process, acromion, and spine, and at the borders and inferior angle of the bone. The greater part of the supra- and infra-spinous fossæ are thin and diaphanous.

DEVELOPMENT.—The scapula arises from eight centres of ossification, as follows: one for the body, which appears at the eighth week; one for the coracoid process, which appears at the first year; and one for the glenoid cavity, embracing the supra-glenoid tubercle. These three centres are primary. The remainder are accessory centres, and may be thus briefly enumerated: one for the base of the acromion, appearing at the fifteenth year; one for the tip of the acromion, appearing at the sixteenth year; one for the base of the coracoid, at the seventeenth year; one for the inferior angle of the bone, at the sixteenth year; and one for the posterior border, at the seventeenth year. The centres for the acromion unite with the spine from the twenty-second to the twenty-fifth year. The marginal epiphyses unite with the body at about the twenty-fifth year. The acromion may exist as a distinct bone. In disjunction of the acromial centre it is not so often the entire acromion as it is the portion bearing the facet that is separate.[1] Even in the normally constituted bone the acromial centre can be distinguished; inferiorly it is of coarser texture than the spine, and everywhere pitted.—The coracoid process beyond the plane of the upper border of the bone is less frequently seen separated than is the acromion. It becomes a very important point to distinguish such a condition from fracture of the coracoid. While it is true that fracture of the process may occur at the point of junction of the centre and the base of the process, it is equally true that it is not apt to occur—the line of fracture

[1] H. Ruge. Zeitschr. für rationale Med., 1859, 258. W. Gruber. Bull. de l'Acad. de St. Petersbourg, 1859.

most commonly involving the neck of the scapula, with which, as has been shown, the process is continuous superiorly.—The centre for the inferior angle is sometimes united to the body of the bone by synchondrosis. Portal mentions the possibility of the detachment of this bone by the violent action of the Latissimus Dorsi muscle.

Remarks.—The variations in the scapula, apart from errors of development, are for the most part confined to the conversion of the supra-scapular notch into a foramen by the ossification of the transverse ligament; to the occasional flattening of the venter above the subscapular angle; and to the exaggeration of the spine in the axillary border.—The articulation between the scapular spine and the clavicle, described under the bone last named, is always accompanied with changes in the form of the spine and the adjacent parts. Should a specimen of a scapula come under notice in which irregular nodosities or ossifications are found attached to the upper border of the spine near the acromion, the inference is reasonable that the clavicle of the corresponding side had secured an articulation to the spine in addition to that of the acromion, and that the nodosities were in some manner associated with such abnormal union.

The coraco-clavicular ligaments are sometimes ossified in whole or in part, and aid in altering the outline of the neck. This occurs either as a result of united fracture of the scapular end of the clavicle, or as a result of the friction of the coracoid process against the clavicle. Under the last-named circumstance an adventitious joint or bursa may be developed, about which irregular ossific growths arise.

Under the action of osteophytes developed about the head of the humerus the glenoid cavity and the neck may be actually bisected as with a knife.

The greatest breadth of the scapula is obtained by a line extending from the centre of the glenoid cavity to the vertebral border; the greatest length by a line extending from the superior to the inferior angle. The length of the infra-spinous fossa is obtained by a line extending from the vertebral end of the spine to the inferior angle. The expression of proportion between the breadth and length has received from Broca[1] the name of the *scapular index*, and the length of the infra-spinous line, taken in connection with the other, the *infra-spinous index*. The standards thus accepted furnish means of examining scapulæ, not only for clinical purposes in health and disease, but for all other purposes of comparison.

The general form of the scapula can be made out in the living subject; the most easily determined features are the spine, the acromion, the vertebral border, and the inferior angle. Holden[1] suggests that measurements of the arms be taken from the junction of the spine and the tip of the coracoid process.—The posterior surface of the acromion is often separated from the skin by a bursa.

The position of the bone may be precisely stated as follows: The scapulæ are five and a half inches apart at the level of the spines, and six inches at the inferior angles. This distance may be lessened in muscular subjects; Meckel[2] states it at two inches. The spine is on a level with the third dorsal spine; it about answers to the division between the upper and the lower lobes of the lungs, and near the vertebral border is on a level with the third intercostal space.

The motions of the scapula are determined by the muscles in connection with it, and by the condition of the thoracic wall; and it may be thus thrown out of position by muscular atrophy or deformity of the spine. The scapulæ can be approximated so that the spines are an inch and a half apart, and the lower angles three inches apart. When widely separated the spines are nine inches apart, and the inferior angles thirteen inches. When the hands are crossed on the head, the inferior angles are sixteen and a half inches apart. In inspiration the scapula moves forward one inch, the spines are five inches apart, and the inferior angles seven inches, while the shoulders assume a square appearance. In respiration the scapulæ drop slightly, and project backward at the inferior angles. These projections, when very pronounced, have received at the hands of the older writers the name of the *scapular wings*. They are specially noticeable in chronic phthisis.[3]

By the motion of the scapula against the ribs, which Henke has somewhat fancifully compared to a ball-and-socket joint, a bursa, *bursa mucosa intra-serrata*, is apt to be developed between the concave scapula and the convex side of the thorax. Gruber has found that in about one-fifth of such instances an elevation of cartilage exists upon the third or the fourth ribs, over which the scapula glides. Dr. R. Herse[4] describes clinically a case in which the above condition was

[1] Bulletin de la Soc. d'Anthropologie de Paris, i. (3d series), 1878, 66; also, W. H. Flower, Journ. of Anat. and Phys. xix. 1879, 13.

[1] Landmarks, 104.

[2] Anatomie, i., 467.

[3] Sibson, Medical Anatomy Col., 45.

[4] N. Y. Med. Journ., xiii. 729

diagnosed. Galvagni[1] describes a crepitation accompanying the scapular movements, which is probably caused by the rubbing of the bone directly against the Serratus Magnus, and indirectly against the ribs.

The scapula may be excised, *and yet the usefulness of the arm be preserved.* Dr. M. Schuppart[2] describes such a condition. The motions of the arm while impaired were reasonably efficient. A weight of thirty pounds could be lifted and thrown a fair distance.

THE HUMERUS.

The humerus (figs. 2 and 3, Plate XXVIII.) is the largest bone of the superior extremity. It articulates above with the scapula, and below with the bones of the forearm. The humerus consists of a head, the anatomical and the surgical necks, the greater and the lesser tuberosities, the shaft, the epitrochlea, the epicondyle, the trochlea, and the radial head. It is convenient in addition to use the terms upper and lower extremities, which, while not exact, assume the bone to be divided into two parts, one above and the other below the junction of the upper third with the lower two-thirds of the shaft.

The *shaft* or *body* is subcylindrical above, and increases in bulk as it approaches the upper extremity; it is somewhat prismatic below, is compressed from before backwards, and is widened as it reaches the lower extremity.

The *head* is a large convex surface, which is a little longer than wide for articulation with the glenoid cavity of the scapula. It represents about a third of a sphere, and is directed upward and inward. It is bounded at its upper two-thirds by a *groove*—better marked behind than in front—known as the *anatomical neck.* To the outer side of the anatomical neck are two prominences, the greater and the lesser tuberosity. The *greater tuberosity* (radial tubercle) is continuous with the shaft, where it is covered by the Deltoid; it is marked on its sides by a number of minute pits and foramina, and above by a smooth surface obscurely divided by three facet-like depressions arranged from within outward for the insertion of the Supra-Spinatus, the Infra-Spinatus, and the Teres Minor muscles. The *lesser tuberosity* (ulnar tubercle) lies to the median side of the former, and is covered by the Biceps muscle. It is less abruptly separated from the shaft than is the greater, and receives the insertion of the Subscapularis muscle.

Between the tuberosities is a deep, vertical depression, the *bicipital groove*, which advances a short distance on the shaft, and receives the long tendon of the Biceps muscle.—The line of the lateral (outer) lip of the groove corresponds to the median border of the greater tuberosity, and also to a ridge that extends downward as far as the middle of the shaft. The ridge is roughened two inches below the head for the insertion of the Pectoralis Major muscle, and at its lower end by the median boundary of an irregular muscular impression (*deltoid impression*) for the insertion of the Deltoid muscle. The deltoid impression itself is a large V-shaped space, and lies on the lateral surface of the shaft.—The line of the median lip of the bicipital groove answering to the lateral border of the lesser tuberosity is less pronounced than the lateral lip. It receives the insertion of the Teres Major and the Latissimus Dorsi muscles.—The portion of the shaft between the insertion of the three muscles above named and the head has received the name of the *surgical neck.* At the median (inner) side of the shaft, at a point on the level of the insertion of the Deltoid muscle, is a faint and narrow impression for the insertion of the Coraco-Brachialis muscle. Immediately beneath the lateral border of the deltoid impression, and extending thence from before backward, is the *spiral groove*, for the musculo-spiral nerve and the superior profunda branch of the brachial artery. The posterior surface of the shaft below the line of the groove is smooth and nearly flat, for the origin of the internal head of the Triceps muscle. The anterior surface below the deltoid impression is abruptly convex, more markedly so above than below, for the origin of the Brachialis Anticus muscle. Separating the anterior from the posterior surfaces are two vertical ridges: the outer, the *supra-condyloid ridge* (supinator ridge), extends from the spiral groove to the epicondyle; the inner, the *supra-trochlear ridge*, extends from the insertion of the Coraco-Brachialis muscle to the epitrochlea. Both these ridges serve to give attachment to inter-muscular septæ. The *foramen for the nutritious artery* (nutritive artery) of the shaft is seen at the upper end of the supra-trochlear ridge, with its orifice directed upward.

The *trochlea* is a cylindroid articular surface, placed transversely to the axis of the bone, and depressed in the centre; it articulates with the greater sigmoid notch of the ulna. The trochlea is broader and deeper behind than in front, and is inclined slightly, so that the middle of the upper trochlear margin in front lies to the median (inner) side of the axis of

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1 Stricker's Medecin. Jahrbuch. 1873, ii.

2 New Orleans Journal of Medicine, Jan. 1870.

the humerus, while behind it is inclined to the lateral (outer) side. The trochlea is more sharply defined medianly than laterally. It is simple and concave behind, but presents in front, in addition to a central concavity, a convexity toward its median side. To the lateral side of the trochlea, and separated from it by a groove, is a well-defined convex surface, *the radial head* (condyle, capitellum), for articulation with the depression on the head of the radius. It is directed forward, and is confined to the anterior aspect of the bone.

Above the trochlea in front is a shallow triangular *depression for the coronoid process of the ulna.* A less distinct impression is seen above the radial head. Directly above the trochlea behind is a broad deep *depression for the olecranon.* To the lateral (outer) side of the radial head is a depression for the external lateral ligament; above it is seen a conspicuous tubercle—the *epicondyle* (external condylar eminence), for the origin of the extensor muscles of the forearm. To the median (inner) side of the trochlea is a process corresponding to the foregoing, but much more conspicuous than it—the *epitrochlea* (internal condylar eminence). This is roughened at the tip for the attachment of the internal lateral ligament of the elbow-joint, and in front for the origin in great part of the flexor muscles of the forearm.—The region of the epicondyle is much thicker than that of the epitrochlea; in some morbid conditions the disproportionate thickness between the two becomes enormously exaggerated.

STRUCTURE.—At the head are presented two sets of lines, a median and a lateral. The median set is composed at its outer border of nearly vertical lines, which pass downward from the upper border of the head to the median border of the anatomical neck. The inner members of this series become curvilinear and shorter as the lower border of the articular surface is reached. Thus the first of the central lines are the longer, and the last the shorter.—The outer set is composed for the most part of vertical lines passing through the greater tuberosity to the lateral wall of the anatomical neck. The median laminæ of this set become more and more oblique, and finally intersect the lateral fibres of the inner set.

At the distal end the laminæ, when seen in transverse longitudinal (frontal) section of the bone, are nearly vertical at the centre, but are moderately concave at their nearest border at the sides. Near the position of the epicondyle and epitrochlea are a number of oblique lines. In the longitudinal antero-posterior (sagittal) section lines are seen to converge from the articular surface to the compressed layer between the olecranon fossa and the depression for the coronoid process of the ulna.—In addition to the above arrangement the epiphysis can be distinguished from the shaft by the fine texture of the cancelli lying beneath the articular surface, and by the coarse and for the most part vertically arranged laminæ of the greater tuberosity. In some specimens the two sets of the shaft, instead of being straight, are slightly curved toward each other.—Notwithstanding the strength of the humerus, numerous examples are on record of its fracture by muscular action.[1]

DEVELOPMENT.—The humerus arises from seven to eight centres of ossification. The first centre appears in the shaft at about the eighth week; the nucleus for the head appears at the second year, and that for the great tuberosity at the third year. The lesser tuberosity, should it have a distinct centre, ossifies at the fifth year. The centres above named coalesce by the fifth year, and constitute the upper or proximal epiphysis. The union between it and the shaft takes place at about the twentieth year. The radial head is the first portion of the distal end of the bone that ossifies, since it receives its centre at the third year. The remaining parts ossify in the following order: the epitrochlea at the fifth year, the trochlea at the eleventh or the twelfth year, and the epicondyle at the eighteenth year. The distal end when completed unites with the shaft at about the sixteenth or the seventeenth year.

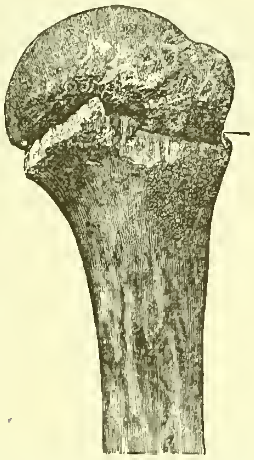
A transverse line drawn below the tuberosities defines the distal limit of the proximal epiphysis, as a similar line uniting the proximal borders of the epitrochlea and the epicondyle defines the proximal limit of the distal epiphysis. Both of the epiphyses may be violently detached in the living subject (Fig. 70). In the event of the proximal epiphysis becoming detached, it has been found by Mr. Jno. Hutchinson[2] that the periosteum is apt to be stripped off from the proximal end of the distal fragment of the shaft, and left attached as a dense cup to the distal edge of the proximal one. This circumstance leaves the epiphysis with more muscular fibres attached to it than would have been the case were a clean section made through the bone and the periosteum. Thus, the Teres Minor muscle is inserted distally to the ephiphyseal line, but

[1] Hamilton on Fractures and Dislocations; and W. Parker, N. Y. Journ. Med., 1852, 95.

[2] Med. Times and Gazette, 1866, 248.

is nevertheless apt to remain with the periosteum belonging to the proximal fragment.[1] The distal epiphysis may be detached entire, or the mass composed of the radial and trochlear centres may remain in

Fig. 70.



Humerus showing separation of the proximal epiphysis.

connection with the shaft, and either the epicondyle or epitrochlea be detached. Luschka mentions an example of the former in which the centre, while detached, still retained a quasi connection with the shaft by cartilage.

Remarks.—The bones of the superior extremity are generally described as though the forearm and the hand were strongly supinated. This position so places the humerus that its deltoid surface moves from an anterior to a lateral (external) position, and its bicipital from a median (internal) to an anterior. The physician, however, will rarely be required in making examinations to place the limb in this unusual position. It is advisable that the bones should be studied as they are seen in the position of rest, namely, with the hand and forearm pronated. Thus seen, the deltoid surface of the humerus is directed forward and slightly outward, and the bicipital groove forward and slightly inward. The lower extremity is not at a right angle to the axis of the trunk, but hangs obliquely so that the epicondyle is on a plane in front of the epitrochlea.

The varieties in the shape of the humerus are not numerous. One of the most striking is an angulation of the shaft at the position of the insertion of the Deltoid muscle, and at first sight it appears to be the result of this muscle's traction on the bone. The shaft above the angle is directed inward and backward, and the bone about the angle is sometimes thicker and rougher than is the rule. The last-named appearance, when taken in conjunction with the apparently *lent* shaft, has caused these specimens to be confounded with others that show effects of fracture. No mistake of this kind need be made if the side *opposite* to the angulation be examined. Should the specimen be one of old fracture, the opposite side will be uneven, while it is quite smooth in the variety of the normal bone just mentioned. The surface of origin of the third head of the Triceps muscle is often convex instead of flat, and may be the seat of localized ostitis.—The bases of the depressions for the olecranon and the coronoid processes may communicate with each other.

Under the name of the *supra-condyloid process* is described as a rare anomaly a slender process projected from the median border of the bone above the internal condyle (epitrochlea). It is supposed to be a rudiment of an osseous bridge that defines a foramen seen in this position in some quadrupeds, as in the dog and the raccoon. The Pronator Radii Teres muscle may arise by means of a thin fibrous band from this process.[1]

The shape of the humerus can be with relative ease defined under the skin. Among the more conspicuous points may be mentioned the greater tuberosity, the general direction of the bicipital groove, the epitrochlea, and the epicondyle. The fingers, pushed well up into the axilla, will be found to reach the shaft at the surgical neck. This method of examination is facilitated by a moderate degree of elevation of the arm.

According to Holden, it is just below the insertion of the Deltoid that ununited fracture of the shaft is seen, partly on account of the injury to the nutritious artery here situated, and partly on account of the action of the Deltoid muscle in causing a riding of the proximal fragment over the distal.—Old persons not infrequently suffer from fracture high up through the tuberosities, just as they are liable to fracture of the neck of the thigh-bone, and of the cancellous structure at the base of the trochanter.[2]

Exostoses have been seen occupying the position of insertion of the Pectoralis Major, the third head of the Triceps at its upper part, and the insertion of the Latissimus Dorsi. When such outgrowths occur, the portion of the shaft below the anatomical neck is

[1] Jno. Hutchinson, Med. Times and Gaz., March 10, 1866, 248.

[1] For literature and figures, see W. Gruber, Mem. Acad. of St. Petersburgh, 1859, 55; also, Jno. Struthers, Edin. Med. Journ., 1848, and Lancet, 1863, i. 87.

[2] Jno. Hutchinson, Med. Times and Gaz., 1866, 303.

remarkably inflated. Exostosis of the greater tuberosity has been successfully removed by operation.[1] The head of the bone has been known to be absorbed, as recorded in a case by Bull.[2]

THE ULNA.

The ulna (fig. 4, Plate XXIX.) is the longer of the two bones of the forearm. It articulates proximally with the trochlea of the humerus, distally with the carpus, and at the lateral side with the radius. It lies to the median side, and to some extent behind the radius. A line drawn downward through the radial head of the humerus would touch the lower end of the ulna.

The ulna is divided into a shaft, an upper and a lower extremity.

The *upper extremity* is of an irregular quadrilateral figure, deeply notched above to form the *greater sigmoid cavity*. The posterior limit of the notch forms the olecranon, and the anterior the coronoid process.

The *olecranon* is continuous with the shaft posteriorly. It forms a massive process, curved slightly forward, and is wider in front than behind. Its posterior surface is rounded for the insertion of the tendon of the Triceps muscle, while the summit is for the most part smooth for the accommodation of a large synovial bursa. A narrow *groove* between the site of the bursa and the free edge designates the line of attachment of the posterior and the lateral portions of the capsular ligament. Beneath the insertion of the tendon of the Triceps muscle is a free triangular surface, with the apex directed distally; the sides are defined by the approximation of the Anconeus and the Extensor Carpi Ulnaris muscles; it constitutes the portion of the bone felt beneath the skin in the undissected subject.

The *coronoid process* is continuous with the front of the ulna. It is a wide, compressed projection, having a broad base, and well-defined sides. Its anterior surface is flat or slightly concave, to receive, by a rough impression toward the median side, the tendon of the Brachialis Anticus muscle. At the base of the coronoid process is a slight elevation termed the *tubercle* for attachment of the oblique ligament. The line of junction at the median side between the coronoid process and the olecranon is depressed to give origin in part to the Flexor Carpi Ulnaris muscle, and to a slip of the Flexor Sublimis Digitorum. The lateral side of the coronoid process is depressed, and marked at the upper half by an elliptical concave articular surface—the *lesser sigmoid cavity*—for articulation with the head of the radius. The bone on either side of this facet is often roughened for the attachment of the orbicular ligament. Below the lesser sigmoid cavity the lateral surface is abruptly concave for the origin of a slip of the Supinator Brevis muscle.

The *greater sigmoid cavity* in articulating with the trochlea of the humerus presents for examination two surfaces, one pertaining to the olecranon and the other to the coronoid process. These surfaces are separated by a transverse groove, which, beginning conspicuously at the middle of the median border, ends faintly at the corresponding point on the lateral border. At a right angle to this notch is a smooth vertical ridge which extends from the centre of the upper margin of the olecranon above to terminate at the anterior free margin of the coronoid process below, and which serves to divide the sigmoid notch into two unequal areas; of these areas the inner is the larger and more concave.

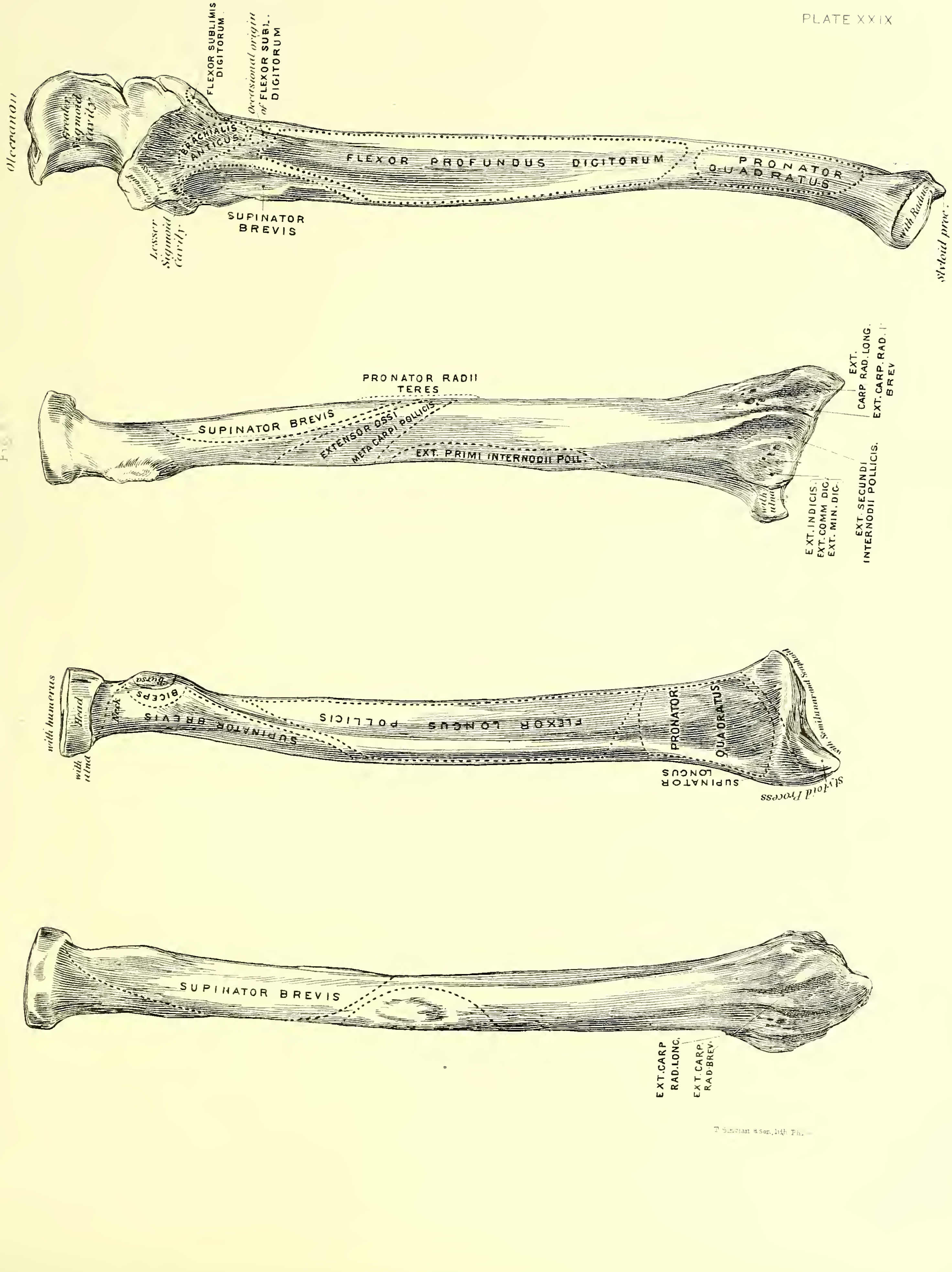
The *shaft* of the ulna is three-sided, and presents accordingly three surfaces for examination, an anterior, a posterior, and a median (inner). The *anterior* and *posterior surfaces* are sharply separated by a thin compressed *ridge*, which is well defined along the middle third of the lateral border, and which serves for the attachment of the interosseous ligament. The median (inner) surface is joined to the anterior by a rounded border, having imperfectly defined limits. The posterior surface is continuous with the anterior surface, excepting at its middle third, where it is separated by the ridge above named.

The details of the shaft, as included within the above-named borders and surfaces, are as follows: the *anterior* surface exhibits a longitudinal depression, for the origin of the Flexor Profundus Digitorum, extending downward and outward from the insertion of the Brachialis Anticus. The *oblique line* serves to separate the surfaces of origin of the Supinator Brevis from the Flexor Sublimis Digitorum; near this line, and toward the median border of the shaft, is seen the *nutritious foramen* directed from the upper extremity of the bone. Toward the distal extremity the anterior surface becomes narrower, and is marked by a line directed downward and inward, for the origin of the Pronator Quadratus. The *posterior* surface is limited laterally above by an *oblique line* or ridge, extending from the posterior border of the lesser sigmoid cavity downward and outward to separate the depression for the insertion of the Anconeus muscle

[1] Lancet, 1864, 210.

[2] Med. Times and Gaz., 1868, 498.

PLATE XXIX


Olecranon
Greater Sigmoid Cavity
FLEXOR SUBLIMIS DIGITORUM.
Occasional origin of FLEXOR SUBL. DIGITORUM
BRACHIALIS ANTICUS
FLEXOR PROFUNDUS DIGITORUM
PRONATOR QUADRATUS
SUPINATOR BREVIS
Lesser Sigmoid Cavity
with Radius
Styloid proc.
PRONATOR RADII TERES
SUPINATOR BREVIS
EXTENSOR OSSI META CARPI POLLICIS
EXT. PRIMI INTERNODII POLL.
EXT. CARP. RAD. LONG.
EXT. CARP. RAD. BREV
EXT. SECUNDI INTERNODII POLLICIS.
EXT. INDICIS.
EXT. COMM DIC.
EXT. MIN. DIC.
with ulna
with humerus
Head
Neck
Bursa
BICEPS
SUPINATOR BREVIS
FLEXOR LONGUS POLLICIS
PRONATOR QUADRATUS
SUPINATOR LONGUS
Styloid Process
SUPINATOR BREVIS
EXT. CARP. RAD. LONG.
EXT. CARP. RAD. BREV.

from the ulnar origin of the Supinator Brevis. To this succeeds a longitudinal *ridge*, whose hinder surface is slightly concave for the origin of the Extensor Carpi Ulnaris muscle. The outer, lower, and rougher parts of the posterior surface give origin to the extensors of the thumb, and in part to the Supinator Brevis muscle. The median border of the posterior surface is for the most part smooth and convex, being broad and concave at its upper portion for origin of the Flexor Profundus Digitorum. It is subcutaneous at its lower fourth.

The *lower extremity* of the ulna is sub-cylindrical in form, and concave on its anterior surface for the Pronator Quadratus muscle. The apparent constriction at this point has received the name of the *neck of the ulna*. The posterior surface is slightly concave for the tendon of the Extensor Carpi Ulnaris muscle. Its median surface is narrow, rounded, and produced posteriorly below the level of the main articular surface, and receives the name of the *styloid process*, and to it is attached the external lateral ligament of the wrist-joint. The tip of the process is covered with cartilage, and forms a constituent part of the joint. The articular surface of the lower extremity of the ulna is termed the *head*. It presents a rounded, nearly vertical lateral border, for articulation with the sigmoid cavity of the radius, and is continuous with the distal surface which is in apposition with the triangular cartilage of the wrist-joint, attached to the notch between the articular surface and the styloid process.

Structure.—The proximal end of the ulna presents a somewhat complex arrangement of laminæ. First in order is a series of nearly vertical lines extending from the great sigmoid fossa to the anterior surface of the shaft. Second, a small group of lines concentric with the curvature of the great sigmoid cavity at its lower half. Third, a series of scattered lines covering the olecranon obliquely from behind forward and downward. Fourth, numerous intersecting arching lines in the remainder of the extremity. The distal end is occupied by oblique, scarcely intersecting lines arranged as in the corresponding end of the radius.

Development.—The ulna arises from three centres of ossification. The nucleus for the shaft appears at about the eighth week; that for the lower extremity at the fourth or fifth year. The upper extremity, so far as it is articular, is an outgrowth from the shaft. An epiphyseal nucleus appears at the tip of the olecranon at the tenth year. This joins the shaft about the seventeenth year. The lower epiphysis unites with the shaft about the twentieth year.

The distal epiphysis has been frequently separated by violence, and in some instances has been necrosed and lost. It is interesting to know that a useful arm may result after this singular lesion. The olecranon and the coracoid process very rarely persist as distinct bones.

Remarks.—The shaft of the ulna is often obliquely deflected at the oblique line.—The olecranon is sometimes broken by a fall on the elbow, the fracture generally taking place at the constriction where the process joins the shaft—thus involving the joint. The coronoid process may be broken off by excessive strain of the Brachialis Anticus muscle. Liston mentions a case of this kind occurring to a boy eight years of age, in consequence of hanging with one hand from the top of a high wall. Fractures of the olecranon and the coracoid process unite, as a rule, by ligament.

When the ulna and the radius are in articulation, it is noticed that the styloid process of the former is somewhat shorter than that of the latter. Both it and the ulnar head can be made out in the undissected subject, lying between the Extensor Carpi Ulnaris and the Extensor Minimi Digiti muscles.

A sesamoid bone is rarely found lying in front of the coronoid process. In a case reported by Fischer,[1] it attained the size of a pigeon's egg.

THE RADIUS.

The radius (figs. 1, 2, 3, Plate XXIV.), while slightly shorter than the ulna, is more massive than that bone, and articulates with the radial head of the humerus above, the carpus below, and the ulna at its median (inner) side in such a manner as to secure movements that are much more varied than are those of the ulna. The part the radius contributes to the formation of the elbow-joint is small compared to that which it contributes to the wrist.

The radius consists of a shaft and an upper and a lower extremity. The bone is narrow and irregularly rounded above, broader and somewhat three-sided below. The *upper extremity* is termed the *head*. It is disk-shaped, with a depression above, as already mentioned, for articulation with the radial head of the humerus. The depression does not occupy the entire proximal facet, for at its inner side a crescentic con-

[1] Langenbeck's Archiv für Chirurg., 1871, xii. 863, figs. 9 and 10, tab. 15.

vexity is seen which articulates with a groove between the radial head and the trochlea. The head presents vertical borders, which are more pronounced within than without, for articulation with the lesser sigmoid cavity of the ulna, and the orbicular ligament. Below the head is a circular constriction—the *neck*. Directly beneath the neck at its anterior surface is the large rounded prominence—the *tuberosity*—the front aspect of which is smooth for the accommodation of a bursa, while the back part is roughened for the insertion of the tendon of the Biceps muscle. The *shaft* of the radius seen from the outer side at the position of the tuberosity is flattened and covered by the Supinator Brevis muscle.

Extending from the position of the tuberosity downward and outward as far as the outer surface of the shaft at about its middle is the *oblique line*. A little below the end of this line lies the roughened impression for the insertion of the Pronator Radii Teres. Thence to the distal end the shaft is somewhat three-sided. The *median* edge or border is sharp and compressed for the attachment of the interosseous ligament. The *lateral* surface or border is broad and convex, and covered by the tendon of the Supinator Longus muscle. The *anterior* surface is nearly smooth, and marked for the upper two-thirds by the origin of the Flexor Longus Pollicis muscle, and below (near the wrist) for the insertion of the Pronator Quadratus muscle. A short distance below the oblique line at the upper third of the shaft is the *nutrient canal*, the orifice of which is directed upward. The *posterior* surface is nearly plane, and covered with the Extensor Communis Digitorum.

The *lower extremity* is larger than the upper. It is somewhat irregularly quadrangular, and marked by the anterior, the lateral, the posterior surfaces (which represent corresponding surfaces of the shaft), and the median (inner) surface which is continuous with the median edge of the shaft.—The *anterior surface* is slightly concave, with sharply defined borders. Its median (ulnar) half projects a little forward, and answers to the semilunar bone; while the lateral (outer) half is deflected downward and outward to form the anterior surface of the *styloid process*, serves for the attachment of the capsular ligament of the wrist-joint, and answers to the scaphoid bone.—The *lateral* (outer) *surface* is broad, and defined in front by the sharp edge separating it from the anterior surface—and behind by a ridge, which is confined for the most part to the shaft, and terminates abruptly a short distance from the articular surface, and which separates the tendons of the extensors of the fingers from the tendons of the extensors of the carpus. The lateral surface is further distinguished by a central ridge confined for the most part to the epiphysis. It passes along the entire length of the styloid process, and separates the groove for the extensor of the metacarpal bone of the thumb, and of the first joint of the thumb, from the extensors of the carpus.—The *posterior surface* is generally described as included within the former. It is limited to that portion of the bone lying between the median and the lateral surfaces. It is nearly smooth, and occupied by the tendons of the extensors of the fingers, and marked at its outer border by a special groove (sometimes absent) for the Extensor Indicis muscle.[1]—The *median* (inner) *surface* is of a triangular shape, narrow above where it is continuous with the inner edge of the shaft, broader below where it joins the carpal surface at a right angle—and presents a facet called the *sigmoid cavity*, which is concave to articulate with the head of the ulna.

The *distal* or *carpal articular surface* is concave, and triangular in form, its base being directed to the median side. Its antero-posterior diameter is marked by a faint ridge which separates the lateral triangular facet for articulation with the scaphoid bone from the median more quadrangular facet for articulation with the semilunar bone.

Structure.—The direction of the laminæ is such that the lines pass downward somewhat convergingly from the proximal articular surface to the inner side of the neck. These are intersected so as to form narrow arch-like figures by lines starting from the sides of the bone. In the distal extremity the lines are oblique and, as such, pass downward from each side to the epiphyseal end, where they terminate with little or no intersection. The lines are more vertical at the outer border. A number of transverse lines are seen in the epiphysis.—In aged subjects the distal epiphyseal end becomes much weakened by reason of the partial atrophy of the cancelli. As a result fracture has not infrequently resulted in comminution of the distal end and inevitable shortening of the shaft of the bone.

Development.—The centre for the shaft of the radius appears between the fifth and the eighth week. The centre for the lower extremity appears at the second year, and unites with the shaft at the twentieth year. The centre for the upper extremity

[1] A portion of the lateral surface is seen in connection with the posterior when the bone is viewed from behind.

(head) appears at the fifth year and unites with the shaft about puberty.

REMARKS.—The shaft of the radius may be deflected inward at the pronator impression.

The position of the radius can be determined in the undissected subject by the shaft. With careful manipulation the tubercle can be made out in forced pronation, while the styloid process and the lateral surface of the inferior extremity can be readily outlined. The advantage secured by defining this surface as distinct from the posterior is decided in studying the relation of the parts at the wrist. The lateral surface is easily detected beneath the skin, and the tendons of the pollical and the carpal extensors can be felt as the thumb and the hand are extended. The posterior surface in the subject cannot be limited medianly, but is bounded by the head of the ulna. The application of these facts in regional anatomy to the study of the lesion of Barton's fracture is so direct as to require no comment.—Surgical writers describe a depression on the lateral side of the ole cranon, which answers to the head of the radius.—J. Kaczande[1] narrates an instance of congenital absence of the radius.

THE CARPUS.

The carpus (Plate XXX.) is a system of irregular bones placed between the bones of the forearm and the metacarpus. It is composed of eight bones, enumerated from the radial to the ulnar border, as follows: the scaphoid, semilunar, cuneiform, pisiform, trapezium, trapezoid, os magnum, and unciform. The figure of the carpus is broader than long, and slightly curved upon itself. It presents a slightly convex dorsal surface, and a concave palmar surface, which is deepened by lateral pressure—the tuberosity of the scaphoid, an oblique process of the trapezium lying at the lateral border, and the hamular process of the unciform at the median. Between these prominences the deep annular ligament is stretched. The proximal surface is smaller than the distal, and is convex for articulation with the radius and the triangular ligament. The distal surface is slightly curved downward, and, excepting a small surface of the trapezium between the first and second metacarpals, which is free, is designed for union with the metacarpus.

The bones of the carpus are arranged in two rows, named, from the proximal to the distal end, the first

[1] Virchow's Archiv, 1877, 409.

and the second row. The *first row* is composed of the scaphoid, semilunar, cuneiform, and pisiform bones; the *second row*, of the trapezium, trapezoid, os magnum, and unciform. Of these the pisiform alone presents but a single facet. The pisiform is the least important of the carpal bones, and pertains more properly to the muscles on the ulnar border of the forearm and hand.

The line between the two rows is called the *inter-carpal* line.

The bones of the first row are so articulated as to yield an arch extending transversely. This is *concave* below, opposite the three outer fingers, in such a way as to secure the scaphoid and the cuneiform bones on the sides of a curve of which the semilunar bone is the centre, and which receives the *convexity* formed by the unciform bone and the os magnum.

Toward the radial border the first row presents a *convex* lateral surface confined to the scaphoid bone, which is received into a *concave* surface composed of the distal facets of the trapezium and the trapezoid bone. Thus the inter-carpal line is sinuous; it is curved forward for the carpal bones, answering in position to the thumb and index finger, and backward for those answering to the middle, the ring, and the little finger.

The bones composing the carpus are free for ligamentous and muscular attachment on the palmar and dorsal surfaces; they are faceted on the remaining sides, except at their entrance into the radial and ulnar border, where they are also free.

STRUCTURE.—Each bone is composed of cancelli, with a thin outer compact layer.

DEVELOPMENT.—Each carpal bone arises from a single centre of ossification.[1] The os magnum ossifies at the first year; the unciform at the second; the cuneiform at the third; the trapezium and the semilunar bones in the fifth; the scaphoid in the sixth and seventh; the trapezoid in the seventh or eighth; and the pisiform at the twelfth year.

The motions of the carpus as a whole are limited to the radio-carpal joint. The second row is capable of being moved upon the first—as in the act of creeping. Here the portions of the hand supporting the weight of the body—viz., the phalanges, the metacarpus, and the second row of carpal bones—are extended upon the first row, which remains in direct

[1] For the statement that the carpal bones may arise from more than one centre each, see Rambault and Renault, Origine et Developpement des Os. Paris, 1867.

line with the vertically placed bones of the forearm. The carpus for the main features of its mechanism is best studied in the act of transmitting the shock received through all the bones from the distal to the proximal ends. Thus, in striking with the fist, the force of the blow is received by the distal ends of the outer four metacarpal bones, through the flexed base of the first row of the phalanges. It is thence transmitted along the bones of the forearm (notably the radius) by means of the convergent axial lines of the carpal bones. Animals walking upon the ends of the toes, such as ruminants, horses, and others, retain the disto-proximal mechanism of the carpus still more conspicuously than does man.

The Scaphoid Bone.—The scaphoid bone (navicular bone) is the first bone of the first row. It articulates with the radius proximally, with the trapezium and the trapezoid distally, and with the os magnum to the ulnar side. The proximal surface is pyriform, the base being directed medianly, and lying in the palmo-dorsal axis of the bone; the distal surface is broader toward the palm than is the dorsum. Between the last-named surfaces a groove extends, which constitutes the dorsum of the bone, and is continuous with the radial border. The ulnar surface is crescentic and convex above for articulation with the semilunar bone, and oblong and concave below for articulation with the os magnum. The radial border is free and roughened for the attachment of the internal lateral ligament at the *scaphoid tubercle*, which can be distinguished during life lying to the median side of the extensors of the thumb.

The Semilunar Bone.—The semilunar bone is placed between the radius proximally, and the os magnum and the unciform bone distally; the scaphoid bone lies to the radial border, and the cuneiform to the ulnar. The proximal surface, which is triangular in form, with the base directed toward the radial border, and the dorsal angle produced, is convex for articulation with the quadrilateral facet of the distal end of the radius. The distal border is bi-faceted—the radial facet being concave for articulation with the os magnum, and the ulnar facet (often inconspicuous) being flat and narrow for articulation with the unciform bone. Both the dorsal and the palmar surfaces are free, the palmar being the larger of the two. Of the lateral surfaces of the semilunar bone the radial is crescentic in form, and smooth for articulation with the scaphoid bone, the ulnar is flat and oblique for articulation with the cuneiform.

The Cuneiform Bone.—The cuneiform bone, as its name implies, resembles a wedge, with its base directed toward the radius. The largest articular surface—the distal—is saddle-shaped, broader above than below, and articulates with the unciform bone. A line carried back from it leads to a free dorso-lateral surface for the attachment of the external lateral ligament of the wrist joint. There is thus no proper proximal surface of the bone. The dorsal surface is roughened for the ligamentous attachment at the ulnar half of the bone, but is convex and smooth for articulation with the fibro-cartilage of the wrist-joint. The palmar surface is irregular and roughened for attachment of ligaments. The radial surface presents a smooth facet for articulation with the semilunar bone; the ulnar is small, oval, smooth for articulation with the pisiform bone; a groove lies between facets of articulation with the pisiform and the unciform bones.

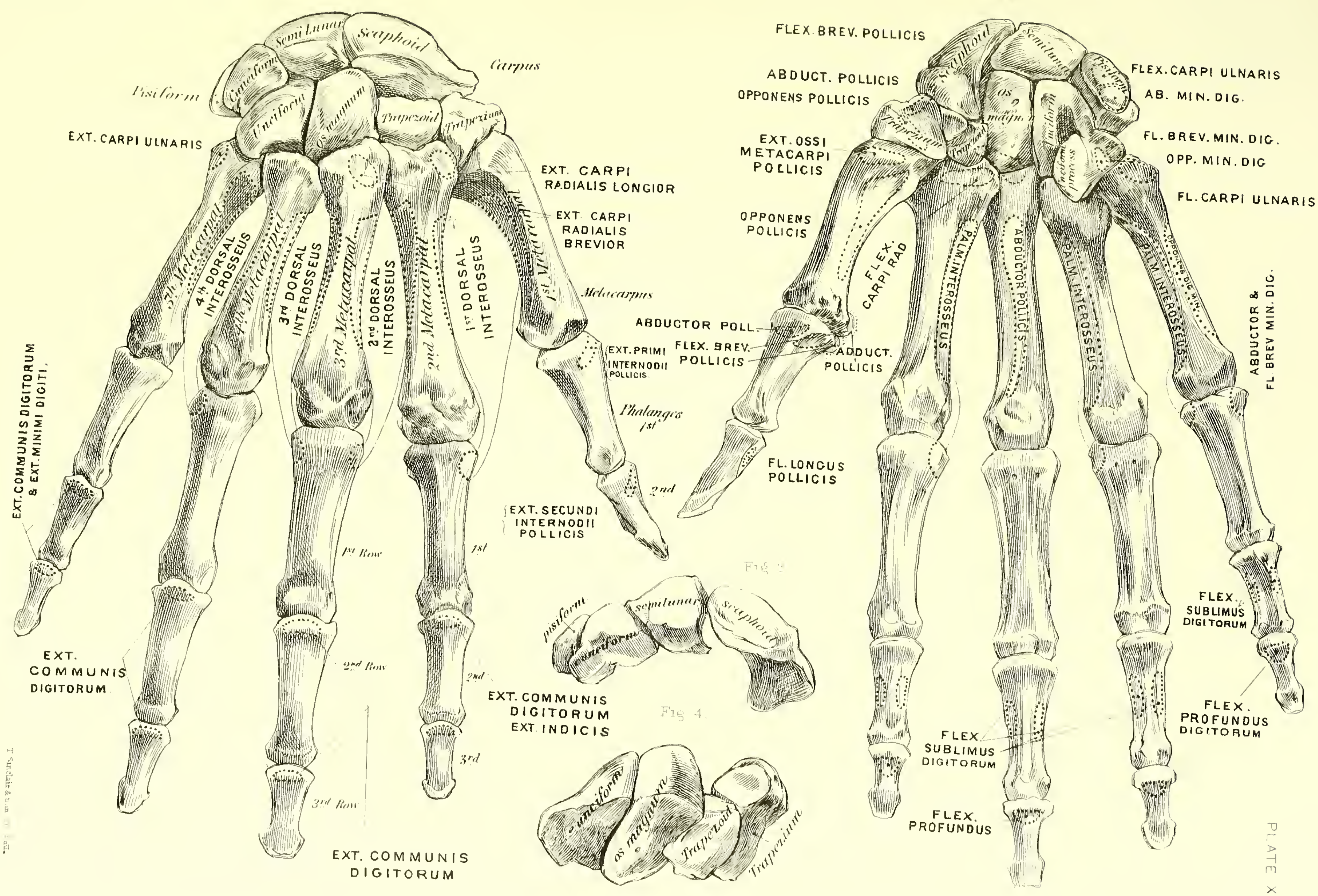
The outline of the bone can be made out in the undissected subject.

The Pisiform Bone.—The pisiform bone lies to the ulnar margin of the first row of the carpus on its palmar surface. It presents a single articular facet for the cuneiform bone, and lies to the ulnar side of the first row of carpal bones. The proximal, the distal, and the ulnar surfaces are free, receive the tendon of the Flexor Carpi Ulnaris muscle, and afford attachment to the external lateral ligaments of the wrist-joint. The bone also presents a facet for the Abductor Minimi Digiti muscles, and gives attachment to the anterior annular ligament.

The position of the pisiform bone can be easily recognized during life.

The Trapezium.—The trapezium is placed in front of the radial half of the distal surface of the scaphoid bone and proximally to the first metacarpal bone. It presents a distal saddle-shaped surface for articulation with the first metacarpal bone, and a proximal concave facet for articulation with the scaphoid bone. The dorsal surface is free, and exhibits two prominent tubercles in front, with an intermediate depression. The palmar surface is the most characteristic, and is marked by a wide compressed oblique process, for the origin of the Abductor Pollicis and the Flexor Brevis Pollicis muscles, and for the attachment of the deep annular ligament, as well as by a groove placed dorsally to the above-named process, for the tendon of the Flexor Carpi Radialis muscle as it passes to its insertion on the second metacarpal bone.

Fig. 1



T. Sinclair & Son, Lith.

PLATE XXX

Of the remaining surfaces, the radial is free and smooth, the ulnar is faceted for articulation with the trapezoid and the second metarcarpal bone. Between the distal facet and the ulnar border is a small portion of the trapezium, which lies free between the first and the second metacarpal bones, and serves for the attachment of a ligament.

Holding the bone with the grooved side downward, the saddle-shaped facet will point to the side to which the bone belongs.

The Trapezoid Bone.—The trapezoid bone is placed between the radial half of the scaphoid bone proximally and the second metacarpal bone distally. It is narrow on the palmar surface, presents a nearly quadrilateral shape through the body, but is broad and irregular on the dorsal surface. The proximal surface is narrow, and yields a slightly concave facet for articulation with the scaphoid bone. The distal surface is saddle-shaped, with a median ridge, and articulates with the second metacarpal bone. The dorsal pentagonal surface is smooth and free, as is also the palmar. The radial surface articulates with the trapezium, and the ulnar with the os magnum.

The Os Magnum.—The os magnum is placed between the semilunar bone and the ulnar surface of the scaphoid on its proximal side, and the third metacarpal bone on its distal side. The trapezoid and a portion of the second metacarpal lie to its radial, and the unciform bone to its ulnar side. The distal surface is triangular, and is concave for articulation with the third metacarpal bone. The proximal end forms the *head* of the bone; it is sub-rounded in form, and convex for articulation with the semilunar bone. The head is convex on its radial side, but flat on the ulnar, and is more conspicuous on the dorsal than on the ventral surface. The dorsal surface is marked by the facet for the semilunar bone proximally, but is broader and more irregular distally. The palmar surface is free, narrow, and convex. The radial surface constitutes a convex facet for articulation with the scaphoid; and a small median surface presents a facet for the trapezoid. The ulnar surface presents a facet along the entire length of the dorsal half of the bone for articulation with the unciform bone, while the palmar half is flat and roughened for ligamentous attachment.

The Unciform Bone —The unciform bone is placed between the semilunar and the cuneiform bones proximally, and the fourth and the fifth metacarpal bones distally. The distal surface presents a large articular surface divided by a ridge into facets, as follows: the facet to the radial side of the ridge articulates with the fourth metacarpal bone, that to the ulnar side with the fifth metacarpal bone. The proximal surface is very oblique, and occupies the entire width of the bone. It is concave toward the ulnar side, convex toward the radial. A faint ridge defines the two facets: the first is very small, narrow, and convex at the radial edge for articulation with the semilunar bone; the second is large and, for the most part, concave for articulation with the cuneiform bone. The palmar surface is very irregular, and is marked, proximally to the fifth metacarpal bone, by a large hook-like process for the attachment of the deep annular ligament, and the origin of the muscles of the little finger. The surface elsewhere is narrowed. The dorsal surface is free. The radial surface is large, faceted nearly the entire surface for articulation with the os magnum; it becomes roughened in front for ligamentous attachment. The ulnar surface is compressed as a thin edge lying between the facet for the cuneiform and that for the fifth metacarpal bone.

Variations in the carpal and metacarpal bones are of four kinds: (1) Duplication of one of the bones; for example, the presence of two semilunar, or two scaphoid bones in the place of one. (2) The existence of the styloid process of the third metacarpal as a distinct bone. (3) The occurrence of an intermediate bone (*os intermedium*) between the scaphoid and the os magnum. This is homologous with a larger bone in the same locality, which is normal in the carpus of some of the quadrumana. (4) A sesamoid bone at the insertion of the Extensor Carpi Ulnaris.

All of the above variations are rare. They have been particularly investigated by Gruber.[1]

THE METACARPUS.

The metacarpus (Plate XXX.) is a series of cylindrical bones placed between the carpus and the first row of phalanges. Each bone consists of a shaft, a proximal (carpal), and a distal extremity. The shaft, which approximates a prism in form (an appearance best seen in the second, the third, and the fourth bones) is slightly concave beneath. The proximal end is flat or concave, and presents in the case of the second, the third, and the fourth bones lateral facets for articulation with the adjoining carpal bones. The distal extremity is rounded, convex, and, with the exception of the first, longer than wide.

[1] Arch. Anat. Physiol. und Wissensch. Med., 1862–76; Bulletin de l'Acad. Imp. St. Petersbourg, 1870–73.

In general outline the first metacarpal bone resembles a phalanx. It is shorter and wider than the others, and is placed at a greater angle to the carpus. It is flat on the dorsal surface, and slightly concave, with a tendency to the formation of a ridge, on the palmar surface near its carpal extremity. The proximal surface is saddle-shaped. The distal surface is produced a little toward the palmar aspect. The articular surface is broader than it is long, and presents on the sides two small facets for the sesamoid bones of the Flexor Brevis Pollicis muscle.

The second metacarpal bone is ridged above at the proximal half of the dorsum for the Dorsal Interosseous muscles. The proximal surface is deeply concave for articulation with the trapezoid bone; and is irregularly faceted for articulation with the trapezium, while the ulnar side articulates with the third metacarpal bone, and at the same time is produced upward and inward to articulate by a small surface with the os magnum.

The third metacarpal bone is a little smaller than the preceding. The proximal surface is triangular, with the apex of the figure truncated and directed toward the palmar surface. It is somewhat oblique, and articulates with the os magnum. At the dorsal surface on the radial border a small process projects upward. The radial border presents a single facet for the second metacarpal bone, and the ulnar has two facets for the fourth metacarpal.

The fourth metacarpal bone is yet smaller than the third. Its proximal extremity presents two facets; one of these, the larger, articulates with the cuneiform bone, while the other is reserved for the os magnum. The radial border yields two facets for articulation with the third metacarpal, while the facet on the ulnar border is single for articulation with the fifth metacarpal bone. The axis of the proximal extremity may be deflected a little to the ulnar side of the axis of the shaft.

The fifth metacarpal bone is more cylindrical than the others of the series. The dorsal surface is marked by a faint oblique ridge, to which are attached, at its radial side, the fourth Dorsal Interosseous muscle, and, at its ulnar side, the tendon of the Extensor Carpi Ulnaris muscle. The proximal extremity presents a wide, saddle-shaped surface for articulation with the unciform bone. A single facet is seen at the lateral side of the end of the bone, while the ulnar side is free.

Synoptical Table of the Metacarpal Bones.

Proximal end with single facet, having a smooth, rounded dorsal border	First and fifth.
Shallow groove running transversely, no facet on either side	First.
" " " " vertically, facet on median side	Fifth.
Proximal end with multiple facets, and uneven dorsal border	Second, third, and fourth.
Palmar border acuminate. Three proximal and two median facets, dorsal border with central notch .	Second.
" " truncate	Third and fourth.
One proximal with two median and two lateral facets; dorsal border without notch, but having a large lateral process	Third.
One proximal, two lateral, and one median facet; dorsal border with neither notch nor process	Fourth.

PHALANGES.

The phalanges (Plate XXX.) constitute the bony framework of the fingers. They are fourteen in number: three to each of the fingers and two to the thumb. The general form of a phalanx is that of a semi-cylinder, the convexity of which is dorsal and the concavity palmar. The proximal end is somewhat larger than the distal. The borders are compressed, and marked on the palmar edges by ridges for the insertion of the tendons of the flexors of the fingers. The phalanges of the first row have their distal surfaces compressed from the dorsal to the palmar aspect, and form a series of narrow, rounded facets (most apparent on the palmar side) for articulation with the second row of bones. The median and lateral borders are each marked with a circular depression, to give attachment to the lateral ligaments. The proximal facet is circular and concave for the reception of the head of the corresponding metacarpal bone, and is marked by two tubercles, the inner of which is commonly the larger.—The phalanges of the second row present, proximally, two small concave facets, separated by a crest ranging from the palmar to the dorsal surface, for articulation with the distal surface of the first phalanx. Upon the sides are two tubercles for the insertion of the lateral ligaments. The first phalanx of the thumb, answering to the second of the other fingers, is distinguished by a body which is without tendinous impressions, and by borders which are smooth and simple; of these the ulnar border is more concave than the radial. The distal surface is not marked by a crest, and the tubercle on the radial side of the articular surface is more pronounced than that on the ulnar. The phalanges of the third row (ungual phalanges) diminish abruptly from the proximal surface forward.

The palmar surfaces are flat, and marked in advance of the distal end by wide expansions for the insertion of the tendons of the Flexor Profundus Digitorum. The crest on the proximal surface is less pronounced than on the phalanges of the second row. The free extremity is rounded and elevated, much roughened, and is marked on the palmar surface by a triangular notch. It serves to support the pulp of the finger tip. The sides of the palmar rugosity may be extended backward as little spines. The terminal phalanx of the thumb is relatively larger than the others. It is markedly asymmetrical, the median border being shorter and more concave than the lateral.

The Sesamoid Bones.—The sesamoid bones are rounded and seed-like in appearance, and are placed in the tendons of the various muscles of the hand at the side of the metacarpo-phalangeal joints. They are best developed at the thumb, where they are lodged in the tendons of the Flexor Brevis Pollicis, the Adductor Pollicis, and the Abductor Pollicis muscles. Similar structures are also found in the tendons of the muscle of the index and little fingers.

For remarks concerning the sesamoid bones see the general considerations of the muscles.

Development.—Each metacarpal bone and phalanx arises from two centres of ossification—one for the shaft or main portion, and one for an epiphysis. In all the metacarpal bones, excepting the first, the epiphyseal centre lies to the distal end of the shaft, but in the first it lies to the proximal end. In the phalanges the epiphyses are without exception proximately disposed. The nuclei of the shafts first appear in the eighth or ninth week; those of the epiphyses from the third to the fifth year. Development is complete at about the twentieth year.

THE BONES OF THE INFERIOR EXTREMITY.

The bones composing the inferior extremity are the innominate bone, the femur, the tibia, the fibula, the tarsus, the metatarsus, the phalanges, and the sesamoid bones—including the patella.

THE INNOMINATE BONE.

The innominate (pelvic, hip, haunch bone) (Plates XXXI., XXXII.) is the largest of the flat bones. It articulates with the sacrum and with the corresponding bone of the opposite side. While forming part of the framework of the trunk, it is included among the bones of the lower extremity. The two innominate bones articulate with the sacrum and the coccyx, and with them make up the *pelvis.*

The innominate bone is subdivided into three distinct portions, viz., the ilium, the pubis, and the ischium,—which are so disposed as to form two expanded, irregular plates, arranged end to end and connected by a narrow *isthmus.* The *upper plate*, which may also receive the name of the *iliac plate*, is flattened from within outward; while the *lower plate*, which may also receive the name of the *ischio-pubic* plate, is flattened from before backward. Intermediate in position to the above plates is the *acetabulum.*

Before describing the bone as a whole, the following brief account of the three component parts will be given.

The *ilium* constitutes the upper plate. In a strict morphological sense, it also includes part of the acetabulum, but for practical purposes it is sufficient to limit it inferiorly at the isthmus. The *pubis* forms the anterior portion of the ischio-pubic plate, and presents a compressed V-shaped figure,—the re-entering angle of which forms the *body*, the upper branch the *horizontal ramus*, and the lower branch the *descending ramus* of the pubis. The *ischium* comprises the posterior part of the ischio-pubic plate. It is more massive than either of the others, and presents in common with the pubis a V-shaped figure whose posterior prismoidal limb forms the *body*, and the anterior flattened part the *ascending ramus.*

A description of the innominate bone includes a lateral and a median surface; four borders; and the obturator foramen.

The *lateral surface* (outer, femoral, external) is more irregular than the median, and is divided into (*a*) the dorsum of the ilium, (*b*) the region of the acetabulum, and (*c*) the lateral surface of the ischio-pubic portion.

(*a*) *The dorsum of the ilium.*—The dorsum of the ilium is a broad, undulating surface that is covered in the undissected subject with the Gluteal and the Tensor Vaginæ Femoris muscles. It is concave at the anterior border, convex on a line with the posterior lip of the acetabulum, again concave for the greater part of the remaining surface, but is convex near the posterior border. Each of these sinuosities answers to some points of anatomical limitation. Thus, the first concavity answers to the origin of the Tensor Vaginæ Femoris, and in part to the surface of origin of the Gluteus Minimus. The first convexity answers to the begin-

ning of the surface of origin of the Gluteus Medius; the large second concavity is entirely occupied by the same muscle; the small second convexity is much roughened for the origin of the iliac fibres of the Gluteus Maximus muscle.—The dorsum is crossed by three faint lines, the superior, the middle, and the inferior, curved lines. The *superior curved line* is in common with the superior iliac border the greater part of its length, but is distinct in a nearly vertical position on the dorsum at the posterior convexity, where it separates the Gluteus Maximus from the Gluteus Medius muscles. The *middle curved line* is well marked anteriorly at the first dorsal convexity, and arching backward ends at the great sciatic notch. It is composed of the lower ends of the oblique rugosities for the origin of the Gluteus Medius muscle. The *inferior semicircular line* begins at the notch above the anterior inferior spinous process, and arches backward nearly concentric to the upper border of the acetabulum; it answers to the lower border of the Gluteus Medius muscle. Along the posterior border of the iliac portion are seen two processes, the *posterior superior spinous process*, and the *posterior inferior spinous process;* these are separated by a faint emargination.

(*b*) *The region of the acetabulum.*—The *acetabulum* (cotyloid cavity, socket for the head of the femur) lies below the narrowed portion of the hip bone (isthmus), and is directed downward, forward, and outward. It is formed by the junction of the main divisions of the bone in such a manner that two-fifths of its area is derived from the ischium, less than two-fifths from the ilium, and nearly one-fifth from the pubis. Nearly circular in shape the acetabulum is for the most part occupied by a C-shaped articular surface. The space between the ends of the curve of this figure is depressed, and directed downward and forward to form the basal and, at the lower and the inner lip, the shallowest part of the socket.

The articular surface is broadest and deepest on the ilium posteriorly where it forms in connection with the ischiatic portion the great *posterior lip;* narrowest on the ilium anteriorly where together with the pubic portion it forms the *anterior lip.* In the last named locality the curve is nearly continuous with the bottom of the socket, but on the ischium the curve corresponds to a rather bold elevation that forms in connection with the bottom the *cotyloid notch* (incisura). The articular surface in the unprepared bone is covered with cartilage, while the depression is filled with fat.—A short distance above the acetabulum a small transverse ridge is seen for the origin of the tendon of the Rectus Femoris muscle.

(*c*) *The lateral surface of the ischio-pubic portion.*—The lateral surface of the *body of the ischium* below the acetabulum exhibits a wide *groove* for the Obturator Externus muscle. On a level with this groove on the posterior margin lies the *spine of the ischium*, for the attachment of the lesser sacro-sciatic ligament and origin of the Superior and the Inferior Gemelli muscles. The ischium ends inferiorly in the *tuberosity*, which presents a broad flat surface looking outward and backward, and yields surfaces of origin for the Biceps, the Semi-Tendinosus, and the Semi-Membranosus muscles. The deep excavation on the posterior margin of the innominate bone between the posterior inferior process of the ilium and the spine of the ischium defines the *great sciatic notch*, which transmits the Pyriformis and the Obturator Internus muscles, the sciatic nerves, the gluteal artery and nerves, and the internal pudic vessels and nerves. The space between the spine of the ischium and the tuberosity has received the name of the *lesser sciatic notch.* The *ascending ramus of the ischium* narrows slightly to join the descending ramus of the pubis; an irregular line of nodules usually exists here to denote the line of sutural union. The lower margin of the ascending ramus is broad, continuous with the tuberosity, and affords a line of origin for the Adductor Magnus muscle. The lateral surface answering to the pubis is smooth on the body and on the greater portion of the *descending ramus*, except at the lower margin and near the symphyseal line, from which the Adductor Longus, the Adductor Brevis, and the Gracilis muscles arise. The massive *horizontal ramus of the pubis* broadens posteriorly towards the acetabulum, and merges into the anterior border of the innominate bone. It is grooved obliquely where it enters into the upper margin of the obturator foramen for the obturator vessels and nerves.

EXPLANATION OF PLATE XXXI.

Fig. 1. The innominate bone seen from the lateral aspect.
Fig. 2. The innominate bone seen from the median aspect.

For "Linea ileo-pectinea" read "Linea ilio-pectinaea."

Fig 1

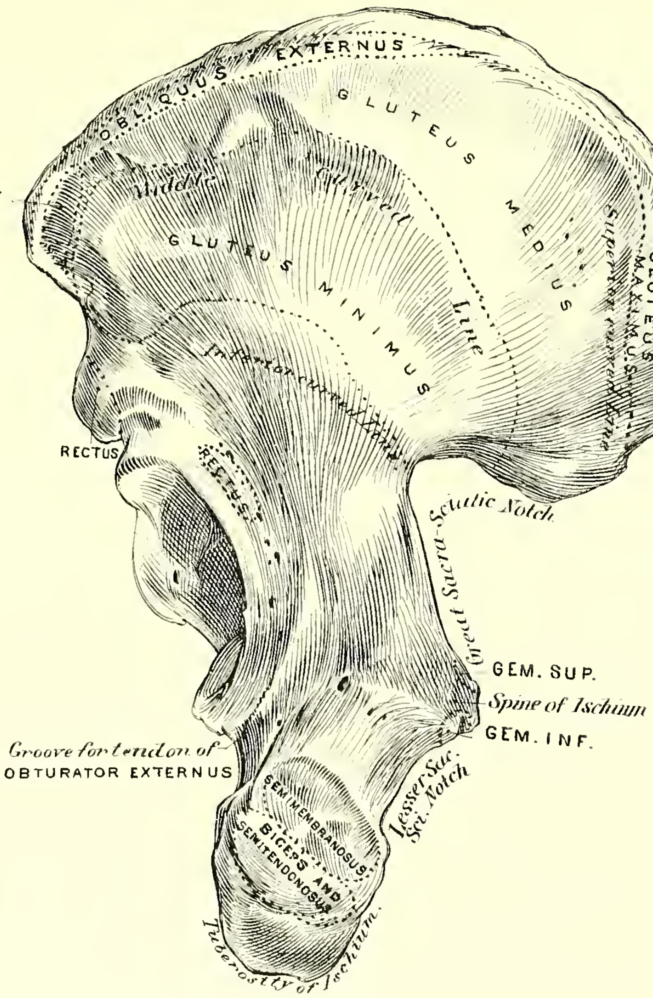
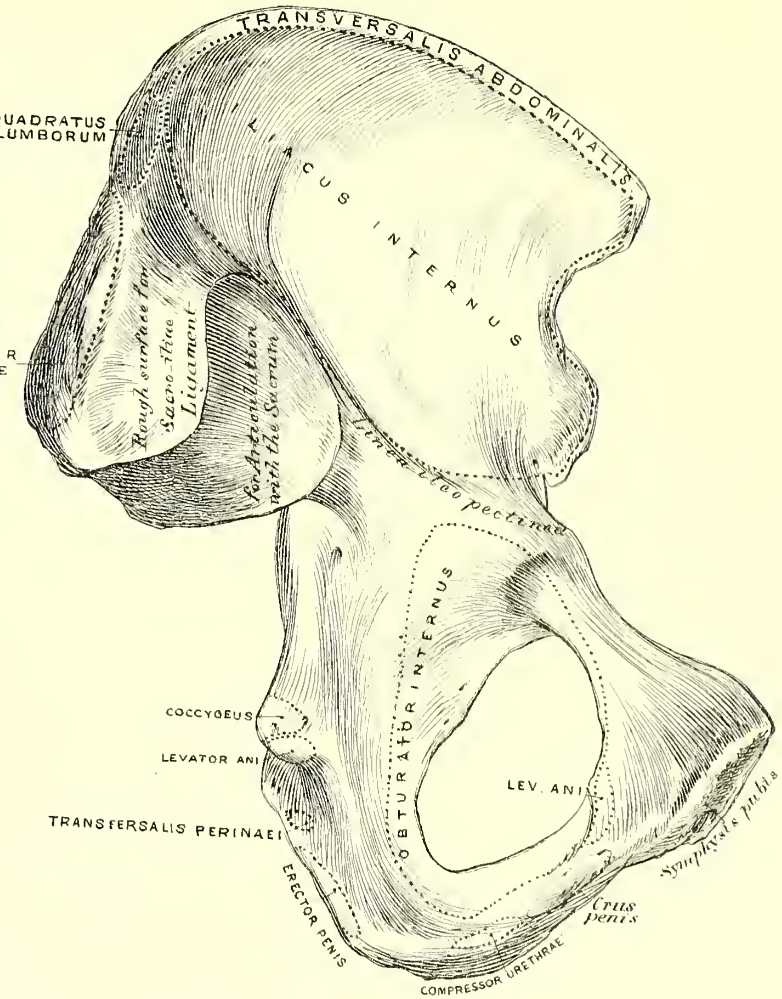


Fig 2



T. Sinclair & Son, Lith.

PLATE XXXI

The *median surface* (pelvic surface) is for the most part divided into the iliac and ischio-pubic portions by a line,—the ilio-pectineal line,—(linea ilio-pectinæa), which extends obliquely downward and forward, from the anterior border of the surface for articulation with the sacrum to near the pubis.

The *iliac portion* is comprised of (*a*) the iliac fossa, (*b*) the facet for articulation with the sacrum, and (*c*) the iliac tuberosity.

(*a*) The *iliac fossa* is smooth and shallow, and occupies the anterior two-thirds of the ilium. It accommodates the Iliacus Internus muscle, and is limited behind by the upper half of the facet of articulation with the sacrum and the anterior edge of the iliac tuberosity, below by the ilio-pectinal line, and in front by the ilio-pubic junction, where a convexity—answering to the line of union between the ilium and the pubis—is seen, constituting the *eminentia ilio-pectinæa*, over which glides the Iliacus Internus muscle. (*b*) *The facet for articulation with the sacrum* (auricular facet) articulates with the lateral surface of the sacrum to effect the sacro-iliac junction. Its inferior posterior border forms the projection known as the *posterior inferior spinous process of the ilium.* (*c*) *The iliac tuberosity* is the rough convexity behind the last-named portion, and, when the bone is in articulation, constitutes part of the dorsal aspect of the trunk. It gives attachment to the sacro-iliac ligament, and in part origin to the Erector Spinæ muscle.

The *ischio-pubic* portion of the median surface is smooth, for the attachment of the Obturator Internus muscle. Under the name of the *ischial planes*, obstetricians indicate the space between the obturator foramen and the great sciatic notch. An imaginary line, extending from the ilio-pectineal eminence to the spine of the ischium, separates the *anterior* from the *posterior ischial* plane. At the lower margin of the ischio-pubic portion are located, in order from before backward, the surfaces of origin of the Coccygeus and of the Levator Ani muscles (a small portion of the origin of the muscle also lying in front of the obturator foramen), the Erector Penis, and the Compressor Urethræ muscles; it further affords attachment to the crus penis, and posteriorly to the great sacro-sciatic ligament. The surface answering to the body of the pubis assists in supporting the bladder. Along the median surface below the obturator foramen lie the internal pudic vessels and nerves.

The *borders* of the innominate bone are the superior, the inferior, the anterior, and the posterior.

The *superior border or the crest of the ilium* follows the convexities and concavities of the dorsum. It is thickest posteriorly where it corresponds to the iliac tuberosity, and thinnest directly in advance of the part last named. Corresponding to the position of the first dorsal convexity, the upper border is abruptly widened, and forms a prominence which is of much clinical significance, since it lies directly in a line with the great femoral trochanter, and serves as a convenient point from which distances can be measured, either to points about the hip, or to any part of the lower extremity. The superior border presents an outer lip, an inner lip, and an intermediate space. The *outer lip* gives origin to the Sartorius, the Tensor Vaginæ Femoris, the External Oblique muscle of the abdomen, the Latissimus Dorsi, the fascia lata, and the beginning of Poupart's ligament. The *inner lip* is designed for the origin of the Transversalis, the Quadratus Lumborum, and, in part, the Erector Spinæ muscle. The *intermediate space* is devoted to the origin in part of the Internal Oblique muscle.

The *inferior border* corresponds to the lower free edge of the descending ramus of the pubis and the lower and the lateral borders of the ischium. From the tuberosity forward to the angle of the pubis the inferior border comprises an *outer* and an *inner lip*, which have already been described under the head of the lower margins of the lateral and the median surfaces. The anterior third of the lower border is broad and oval, and constitutes the articular surface that forms in connection with the corresponding facet of the opposite bone the *symphysis pubis.*

The *anterior border* presents the following points in order from above downward. First, the *anterior superior spinous process*, from which and the lateral border of the crest the Sartorius muscle arises. Second, an emargination. Third, the *anterior inferior spinous process*, for the origin of the long head of the Rectus Femoris muscle, and attachment of the ilio-femoral fascicle of the capsular ligament. Fourth, the thin compressed anterior acetabular lip. Fifth, the broad triangular surface whose apex is directed forward and inward to form, at the junction of the anterior with the inferior borders, the *angle.* Sixth, the *pubic spine*, which is placed at the upper and anterior part of the body of the pubis, and is designed for the attachment of Poupart's ligament and the conjoined tendon. The interval between the spine and the angle gives origin to the External Oblique and the Pyramidalis muscles. Seventh, a surface for the origin of the Pectineus muscle.

The *posterior border* lies between the superior and

the inferior borders. It is thin and compressed in the iliac and acetabular portions, but is robust below. The posterior border embraces the posterior superior, and the posterior inferior spinous processes, the greater and the lesser sciatic notches, the ischiatic spine, and the ischiatic tuberosity. These have been described in connection with the lateral surface.

The *obturator foramen* is a large oval or triangular opening with sub-rounded angles, and is defined by borders derived from the pubis and the ischium. It is marked above by a faint prominence near the cotyloid notch, and below by another near the pubo-ischiatic junction. The foramen in life is occupied by a firm fibrous membrane which is covered laterally by the Obturator Externus muscle, and medianly by the Obturator Internus. It is pierced above by the obturator vessels and nerve.

Structure. — The greatest amount of compact tissue of the innominate bone is found in the curve of great sciatic notch and the bone extending thence beneath the spine of the ischium. The compact tissue is also well developed at the articular surface of the acetabulum and the dorsum of the ilium. The main bulk of the bone, however, is spongy, even the iliac and the ischiatic tuberosities being in great part composed of cancelli. The laminæ about the acetabulum are coarser than elsewhere, and exhibit radiating fibres which pass from the socket laterally, and which are intersected by others answering to the curvatures of this portion of the bone. The centre of the iliac fossa, which is the thinnest portion of the ilium, is, as a rule, translucent. In the negro the bone is massive, and the translucent appearance above mentioned is absent.

Development.—The innominate bone arises from eight centres of ossification. The first centre appears in the ilium at about the eighth week; the second, in the ischium at the third month; the third, in the pubis at the fifth month. The remaining centres are accessory to the above. The ilium exhibits two secondary points of ossification, the one for the crest, the other for the anterior inferior spinous process. The ischium retains one centre for the tuberosity; and the pubis also one for the symphyseal surface. The pubis and the ischium unite by their adjoined rami at about the eighth year. After the three main portions of the innominate bone have contributed to define the acetabulum, there still remains intermediate to their opposed surfaces at the bottom of the socket, a Y-shaped piece of cartilage, within which at about the eighth year, a nucleus of bone, retaining the shape of the cartilage, appears; this nucleus, while not serving as an epiphysis to any of the innominate segments, unites therewith about the twentieth year.

Remarks.—The innominate bone presents many varieties in the proportions and in the degrees of massiveness of the several parts composing it, while yielding but few distinct variations of minor character. Malgaigne invites attention to the fact that the projection of the first convexity of the dorsum of the ilium forms a dividing line of surgical significance. In fracture near the crest he finds the lines extending either from the portion in front of the convexity backward or from a point back of the convexity forward.—Osteophytes have been noted arising from the ilio-pectineal line to a sufficient height to serve as an exciting cause of uterine laceration during labor.[1]—The posterior lip is liable to be broken in dislocation of the head of the femur backward. Mr. H. Morris[2] believes that such fracture always occurs. This extreme position is controverted by Mr. F. S. Eve,[3] who, while accepting the fact that the lesion may occur, mentions three instances in which the acetabulum remained intact. It must be borne in mind that the dislocation is assumed to take place by such violence as to thrust the femur upward and backward.

In the living subject the crest of the ilium, and the lateral aspects of the ischium and the pubis can be in a measure discerned beneath the integument. In vaginal examinations with the finger the median surfaces of the pubis and the ischium can be outlined, while the spine of the ischium can be recognized with distinctness.—The highest point of the ilium is about on the level of the spine of the fourth lumbar vertebra.—The anterior superior spinous process is a little below the level of the promontory of the sacrum.

THE PELVIS.

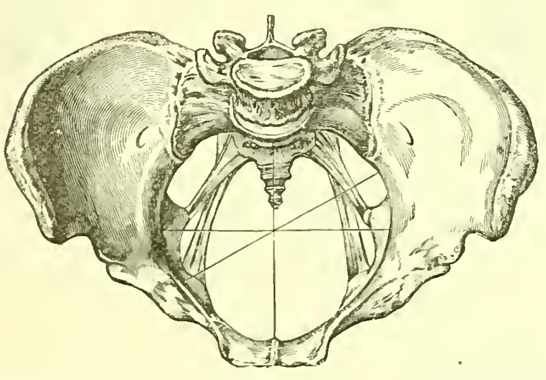
The pelvis (Fig. 1, Plate XXXII.) is the figure resulting from the union of the innominate bones with the sacrum and the coccyx. The artificial pelvis closely resembles the ligamentous, the most important distinction lying in the inferio-lateral portion, where the great sciatic ligament modifies the shape of the outlet of the osseous pelvis.

[1] New York Medical Journal, xi. 424.
[2] Med.-Chir. Trans., lx. 161.
[3] Med.-Chir. Trans., lxii. 51.

The pelvis receives its name from its rude resemblance to a basin. The brim of the basin must be considered as broken in front and behind; the latter opening, however, is in part occupied by the last lumbar vertebra.

The pelvis is divided by the ilio-pectineal line, and by the portions answering to the production of this line backward upon the sacrum, and forward upon the pubis, into the *true* and the *false* pelvis. The *false pelvis* (great pelvis) is in connection with the wall of the abdomen, which it aids to support; it is concave for the accommodation in part of the intestinal coil, and for the ovaries and the beginning of the Fallopian tubes in the female. The *true pelvis* (lesser pelvis) accommodates the internal organs of generation, the rectum, and in part the bladder. It is closed inferiorly by the perineum. The superior outlet of the true pelvis is called the *brim*, or the *superior strait*. Its figure is cardiform, the base answering to the promontory of the sacrum, the sides and the apex to the ilio-pectineal line. The inferior outlet is called the *inferior strait* or *outlet*. It is of an irregular outline. In front it answers to the triangular space defined by the conjunction of the ascending limb of the ischium and the descending limb of the pubis on each side of the symphysis pubis; at the sides it answers to the double sinuate line, extending from the tuberosity of the ischium to the sacrum. As already mentioned, the great sacro-sciatic ligament defines the inferior strait laterally in the ligamentous pelvis. The walls of the true pelvis are straight and smooth at the sides and at the back, and concave at the back and the front.

Fig. 71.



The pelvis seen from above, showing the position of the sagittal, frontal, and oblique diameters.

The Diameters of the Pelvis. (Fig. 71.)—The importance of a knowledge of the pelvis in connection with the science of obstetrics has led observers to carefully define its diameters. These will be presented in the following order:—

The conjugate diameter (antero-posterior, sagittal) of Nägele is a line drawn from the promontory of the sacrum to the superior margin of the symphysis pubis. It measures at the

Superior strait	$4\frac{1}{2}$ inches.
Cavity	$5\frac{1}{4}$ "
Inferior strait	5 "

The transverse diameter is a line drawn between the acetabula, as follows:—

Superior strait	$5\frac{1}{4}$ inches.
Cavity	$4\frac{3}{4}$–5 "
Inferior strait	4–$4\frac{3}{4}$ "

The following are the oblique diameters:—

Superior strait	5 inches.
Cavity	$5\frac{1}{4}$ "
Inferior straight . . .	$4\frac{3}{4}$ "

The pelvis not being exactly symmetrical, the right oblique diameter is somewhat shorter than the left.

Hermann Meyer describes a diameter named by him the *normal conjugate.* This line passes from the middle of the anterior surface of the third sacral vertebra to the upper border of the symphysis pubis. It is accepted as a more constant measurement than the conjugate, since it is not subject to material variation from the position of the pelvis or from the vertebral column. Meyer recommends in order to make satisfactory measurements of the pelvis that the observer place the anterior superior spinous process of the ilium and the spine of the pubis on the same vertical line, the body to be erect, as in the act of standing, and the limbs to be neither abducted nor adducted.

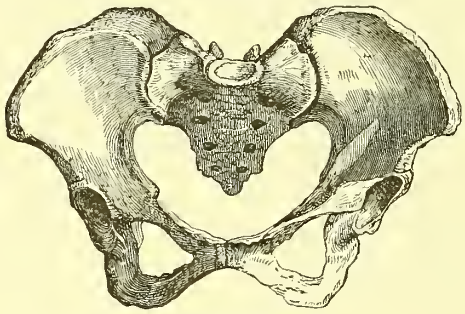
The most important of the external measurements of the pelvis are the following:—

Between the anterior superior spinous processes, 10 inches; between the central points of the crests of the ilia, 10 inches; between the spinous process of the last lumbar vertebra and the upper border of the symphysis pubis (external conjugate), 7 inches.

The pelvis presents some striking *sex distinctions.* Thus the bones of the female pelvis (Fig. 72) are lighter in structure than are those of the male; the true pelvis is wide and short, and possesses a cylindrical figure, which, in the child-bearing woman, is so modified as to be slightly increased in its transverse over its antero-posterior diameter. In the male (fig. 1, Plate XXXII.), the true pelvis is narrow and high, and the figure is somewhat ovate from before back-

ward. In the female the sub-pubic arch is wide and rounded at the symphysis, and forms an angle of about 90° to 100°; in the male the arch is angulated, and forms an angle of from 70° to 75°; in this sex the obturator foramen is also of a triangular figure.

Fig. 72.



The female pelvis.

Race distinctions can also be determined as well as those of sex. In the negro the transverse diameter is less than in the white. The race distinctions of the pelvis have been made the subject of elaborate study by Mr. J. G. Garson.[1]

Fig. 73.

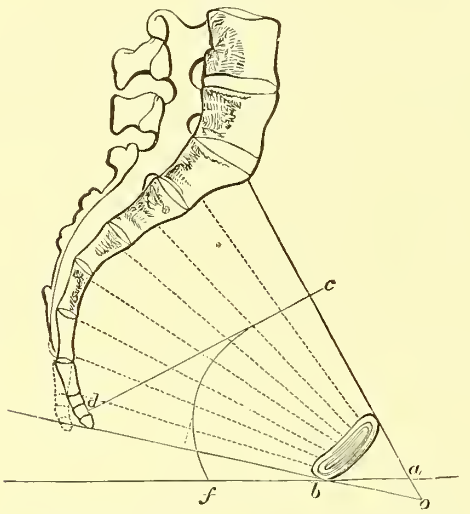


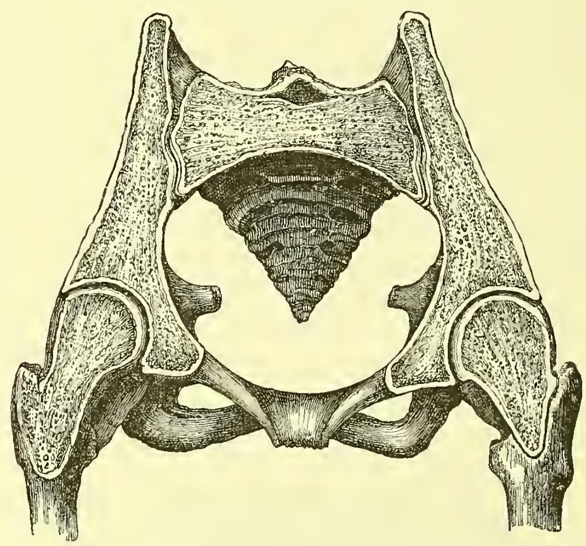
Diagram showing the inclination and axis of the true pelvis.

[1] Journal of Anatomy and Physiol., vol. xvi., Part I., 1881, 106 (figs.).

The *axis of the pelvis* is the sum of the lines uniting the centres of geometrical planes defined within the cavity of the true pelvis. This has been described as an irregular parabola. Considered as representing the line of descent of the body of the child during delivery the pelvic axis, as above defined, is approximately true only, since the pelvis, considered as a ligamentous or an artificial structure, retains, to an imperfect degree, the diameters of the inferior strait.

Mechanism of the Pelvis.—The pelvis is sustained in its relation to the trunk by the sacro-lumbar articulation, and with the lower extremity by the hip-joint. It is inclined slightly downward and forward, so that the plane of the superior strait assumes to a horizontal plane an angle of 55° to 65°. The exact degree of angulation present is determined by the amount of flexure in the lumbar vertebræ. The bones of the pelvis are not immovably fixed, but permit a moderate amount of motion to occur normally between one another.

Fig. 74.



Section of pelvis showing the suspensory action of the sacro-iliac ligaments.

While sustaining the weight of the body, the sacrum, being broader behind than in front, would slip forward, if the motion were not checked by the stout ligaments uniting it with the innominate bone. The

EXPLANATION OF PLATE XXXII.

Fig. 1. The male pelvis seen from in front—the coccyx is absent.

Fig. 2. The innominate bone seen from in front.

PLATE XXXII

Fig. 1

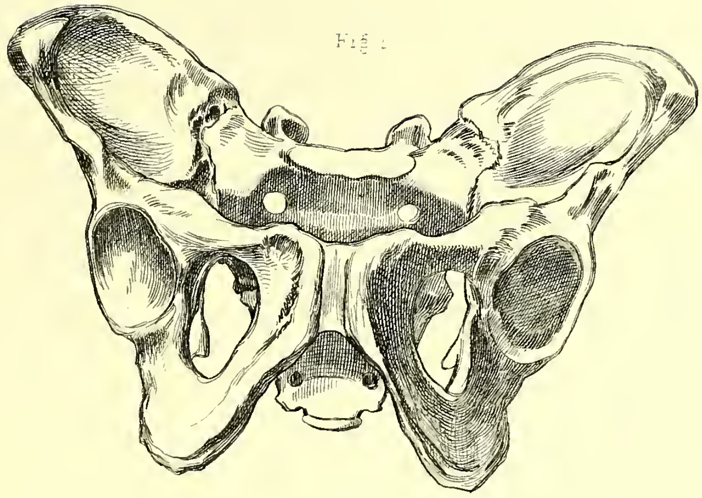
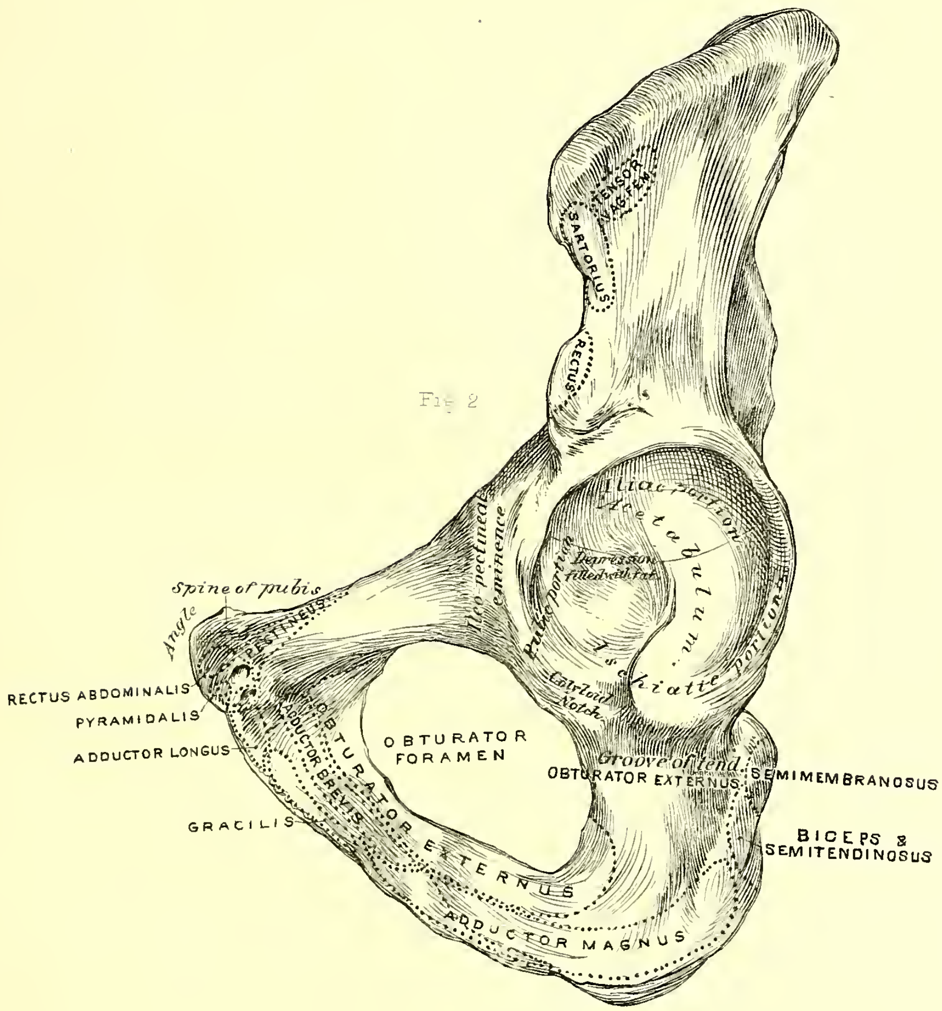


Fig. 2



Sinclair & Son, lith.

posterior of these ligaments, while thus checking the movement downward, will cause a slight degree of motion to take place at the symphysis. The latter, therefore, bears a direct relation to the amount of pressure forward of the sacrum against and between the innominate bones.—The lower part of the sacrum is so firmly fixed to the hip-bones by the sacro-sciatic ligaments (*i. e.*, on a plane below that of the symphysis pubis) as not to permit of motion. The pelvis when deformed, as in rickets, exhibits the greatest degree of deformity at and above the symphysis,—a result, it is thought, of the difference of effect of sacral pressure upon the innominate bone at and above the pubis, as contrasted with pressure below this bone.

In standing, the weight of the trunk rests upon the inferior extremities at the acetabula, and upon lines extending thence to the sacrum. The arch defined by connecting these lines has received the name of the *cotylo-sacral arch.* The line extending from the acetabula round the anterior surface of the true pelvis has received the name of the *cotylo-pubic tie.* In sitting, the weight of the body is borne by the tuberosities of the ischia, and is thence transmitted by arched lines to the sacrum. The sum of these lines has received the name of the *ischio-sacral arch*, and the line extending thence to the pubis the name of the *ischio-pubic tie.*[1]

THE FEMUR.

The femur or thigh-bone (Plate XXXIII.) is at once the longest and the largest bone in the body. It articulates above with the innominate bone and below with the tibia and the patella. When the lower extremity of the femur is placed with the condyles resting on the same plane, as in articulation, the axis of the shaft is oblique to a line dropped through the centre of the trunk.

The bone is divided into a shaft and two extremities.

The *shaft* is massive, compact, moderately curved upon itself from above downward, and twisted at its upper third. It presents in front and at the sides convex surfaces; of these the posterior is roughened above and ridged for muscular attachments, but is flat below where it enters into the popliteal space. Cylindroid or prismatic, with rounded angles at the middle third, the shaft is compressed, widened, and irregular both at the upper and at the lower thirds. —The *middle third of the shaft* is smooth in front, and narrowed behind to form a prominent ridge called the *linea aspera*, which presents for examination two lips and an intermediate space. The *lateral* (outer) *lip*, the more prominent of the two, receives the insertion of the central portion of the Vastus Externus; the *median* (inner) lip receives the corresponding part of the Vastus Internus; the *intermediate space* is occupied by the insertion in part of the Adductor Magnus muscle.—The *upper third of the shaft*, as already mentioned, appears to be slightly twisted upon the lower two-thirds. It is robust and subcylindrical, and presents a smooth anterior surface, somewhat flattened, and a rough posterior surface, upon which is a ridge continuous with the linea aspera. The lateral lip of this ridge is designed for the insertion of the Vastus Externus, and is directed nearly vertically upward to the lateral aspect of the base of the lesser trochanter. Still further to the lateral side of this line, namely at a point about two inches below the upper end of the shaft, is seen a deep narrow depression for the insertion of the Gluteus Maximus. The continuation of the median lip becomes, as it appears upon the median surface of the bone, the *spiral line*, which winds upward and inward round the lesser trochanter to the front of the shaft, where it ends in the *tubercle*, a rounded prominence situated at the anterior border of the great trochanter. The lower part of the spiral line in front of the lesser trochanter receives the insertion of the Pectineus muscle. W. Roger Williams[1] proposes the name of *inferior cervical tubercle* for a moderate elevation at the middle of the spiral line to which the Vastus Internus muscle effects important attachments. As distinguished from this the same writer calls the tubercle at the top of the spiral line the *superior cervical tubercle.* Above, the spiral line gives origin to the Vastus Internus muscle, and in front of the femur to the Cruræus. In the space defined by the lines above described are inserted the Adductor Longus and the Adductor Brevis muscles.—The *lower third of the shaft* is much broader than the upper, and is marked laterally and behind by the lines of the linea aspera as they pass to the condyles, the external of the two lines being the more prominent. The median line near its point of separation from the linea aspera is interrupted by the femoral artery as it winds round the femur to become the popliteal. Upon this line above thi enternal condyles is a minute spur-like *tubercle* corresponding in position to the highest point of the patellar groove as well as to the junction of the shaft with the epiphysis. It is designed for the insertion of the long tendon of the Adductor Mag-

[1] John Wood, art. Pelvis, Cyclopædia of Anatomy and Physiology (Supplement), 1859.

[1] Journ. Anat. and Phys. 1879.

nus muscle. The shaft is nourished by a branch of the femoral artery which enters a *canal* situated about the junction of the middle and the upper third of the shaft, and is directed upward.

The *upper extremity of the femur* presents for examination the head, the neck, the great trochanter, and the lesser trochanter.

The *head* is large and rounded, and enters into the construction of the hip joint. It corresponds in position to a vertical line produced upward from the inner condyle. Describing nearly two-thirds of a sphere, the head presents a larger articular surface above than below the transverse plane, and projects over the neck more sharply below than above. At the lateral margin the head is continuous with the front of the neck, and extends thereon a few lines beyond the general articular surface. A little below and behind the centre of the head is a shallow circular *depression* for the attachment of the ligamentum teres. Elsewhere the head is separated from the neck by a shallow groove. With the exception of the depression for the ligamentum teres the head of the femur is covered with cartilage in the living subject.

The *neck* is a broad process of bone directed obliquely upward and inward from the upper end of the shaft at an angle of about 130°. Compressed from before backward, its anterior part is much flatter than the posterior, and presents, as a rule, a long narrow oblique border below, and a straight rounded more horizontal border above, which is perforated with numerous venous foramina. The neck is marked in front near the articular surface by a faint depression, which is often cribriform in appearance, and may receive the name of the *cervical fossa*. The neck is limited below by the inter-trochanteric line, and in front by the spiral line. A number of small *nutritious foramina* are seen on the hinder aspect of the neck at its base.

The *great trochanter* (trochanter major) is a large process continuous with the shaft and inclined to its lateral side. It lies on a lower level than the head, namely about three-quarters of an inch, and when the femur is in articulation it is nearly on a level with the spine of the pubis. It is irregularly quadrilateral in shape, the posterior border being imperfect. The *anterior border* is limited about the position of the tubercle at the point where the Vastus Externus and the Gluteus Maximus muscles meet. The *superior border* is rounded, and serves behind at its free portion for the insertion of the Pyriformis, and in part, where it is continuous with the neck, for the insertion of the Obturator Internus. At the angle of junction of the superior and the anterior borders, the Gluteus Minimus is inserted, while the corresponding angle between the superior and the posterior borders forms a prominent *process*, which lies about on a level with the depression for the ligamentum teres. The *inferior border* is obscure, and answers to the line of union of the trochanteric epiphysis with the shaft. The *anterior surface* of the great trochanter is flat. The *posterior surface* is large and convex, and is crossed obliquely from above downward and forward and from within outward by a faint *ridge* which limits inferiorly the space for the insertion of the Gluteus Medius muscle. Below this ridge is a smooth surface (covered by a bursa in the subject) over which glides the Gluteus Maximus. The *median surface* is depressed to form the *digital fossa*, into which is inserted the tendon of the Obturator Externus, and, in part, that of the Obturator Internus.

The *lesser trochanter* (trochanter minor) is designed to receive the insertion of the conjoined tendon of the Iliacus Internus and the Psoas Magnus muscles. It is situated below and behind the base of the neck, and is directed inward and backward. It is somewhat nipple-shaped, and presents a posterior surface which is smooth, and on the plane of the general posterior aspect of the bone at this point. The anterior, superior, and inferior surfaces are free; the last serve to support the process from below. The summit of the lesser trochanter is, in the living subject, covered by a bursa over which glides the Quadratus Femoris muscle.

Under the name of the *intertrochanteric line* is included a prominent ridge extending obliquely down-

EXPLANATION OF PLATE XXXIII.

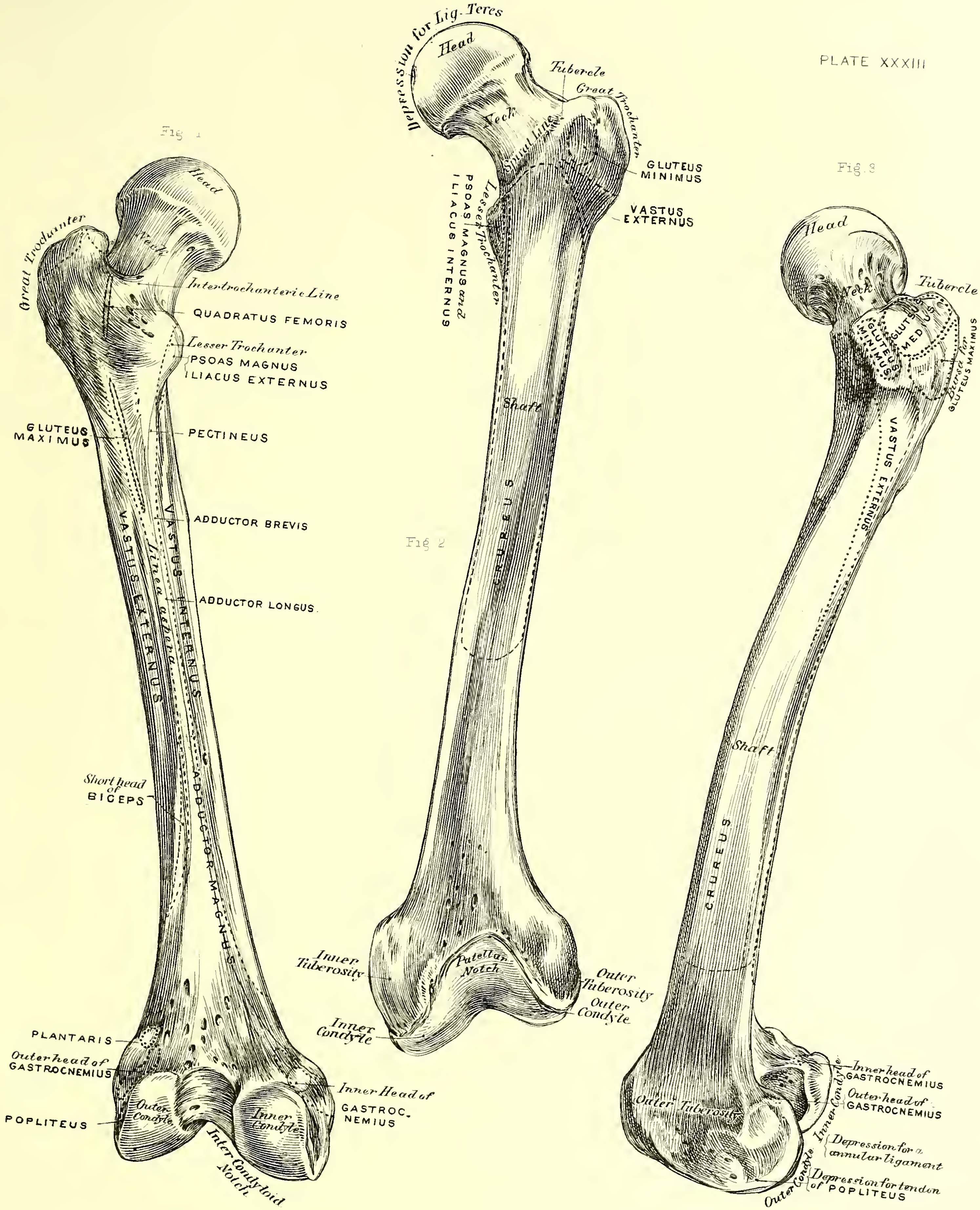
Fig. 1. The femur seen from behind in natural position.

Fig. 2. The femur seen from in front in conventional position.

Fig. 3. The femur seen from the lateral aspect in the natural position.

The words "Depression for annular ligament" should be omitted.

PLATE XXXIII



ward and inward, and joining the inferior border of the great trochanter with the lesser trochanter. It limits the base of the neck. At a right angle to the above-mentioned line the Quadratus Femoris muscle is inserted.

The *lower extremity* of the femur is broad, and transversely flattened, and is wider behind than in front. It presents for examination an external (lateral) and an inner (median) condyle, together with the inter-condyloid notch and the patellar groove.—The *external condyle* yields a lateral, nearly flat border, which is continuous with the lateral surface of the shaft. The articular surface is convex and broad, but narrowed slightly as it approaches the posterior surface, where it terminates in a horizontal border. Above it lies a faint *impression* for the origin of the lateral (outer) head of the Gastrocnemius muscle. The lateral surface presents a rounded eminence called the *external tuberosity*. Below this the surface is marked by a pronounced *depression* for the external lateral ligament, and the *groove* for the Popliteus muscle.—The *internal condyle* is inclined obliquely inward and slightly downward, and broadens at its posterior oblique border. Above is a *depression* for the origin of the median (inner) head of the Gastrocnemius muscle and the *internal tuberosity* (corresponding in position with the eminence on the external condyle) for the attachment of the internal lateral ligament.

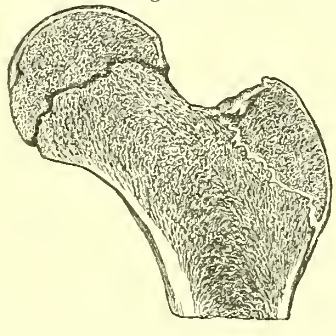
When the isolated bone is placed in a vertical position, the inner condyle descends below the level of the outer; this effect disappears when the bone is placed as in articulation.

Posteriorly the condyles are separated by a deep notch — the *intercondyloid notch* — whose opposed lateral surfaces and base are concave for the attachment of the crucial ligaments.—The condyles are continuous anteriorly by means of a shallow, saddle-shaped surface, termed the *patellar groove*, whose deepest convexity lies on a level with the top of the inter-condyloid notch posteriorly, and whose greatest convexity lies to the outer side of this depression. The notch answers to the resting-place of the patella in the position of the thigh in extension. Above the patellar notch is a long, shallow excavation, covered in the fresh state with thick periosteum, and furnished with orifices for veins.

Structure.—The walls of the shaft are enormously thick, the median being somewhat the heavier. The *proximal end* of the bone exhibits five sets of lines in the spongy tissue, which are limited abruptly inferiorly at a little below the level of the trochanter minor, and thence extend through the upper portion of the bone. The *first* set are confined to the head, and, indeed, distinguish its epiphysis throughout life. The lines are arranged in close series, radiately to the curve of the articular surface. The line of junction with the neck is at times marked by a number of coarser interspaces than those seen elsewhere. The *second* set begin opposite the trochanter minor, and pass upward to the epiphyseal junction, which it for the most part occupies, as a cluster of straight, stout lamellæ. In some specimens these lines are so closely serried as to present the appearance of compact tissue. Toward the proximal end of the lower border they are weaker. The *third* set are coarse, and range from opposite the lesser trochanter down to the lower limit of the spongy area. They serve to faintly intersect the *fourth* set, which are the strongest and the best developed. These range curvilinearly from the lateral border of the line at and below the base of the great trochanter to the upper portion of the epiphyseal junction. Some of the stouter of these lines, as they range from the upper border of the neck toward its axis, may be continuous with the weak upper border, as described by H. C. Bigelow.[1] The *fifth* set are the loosely arranged and weak cancelli of the great trochanter.—The *distal end* of the bone is occupied by a set of stout, nearly vertical lines in the outer condyle, which pass thence to the outer side of the shaft, and a second much weaker and more oblique set in the inner condyle. A number of weak transverse lines intersect the foregoing at right angles.

Development.—The femur arises from five centres of ossification. The first appears in the shaft at about the fifth to the seventh week. The second appears in the condylar epiphysis at the ninth month of fœtal

Fig. 75.



A longitudinal section of the head and neck of the femur, showing the positions of the epiphyses for the head and the great trochanter.

[1] The Hip, p. 120.

life. The third appears in the head of the bone at the end of the first year. To these are added, as secondary ossifications, the centre for the great trochanter at the fourth year, and the centre for the lesser trochanter at the thirteenth year.

The lesser trochanter unites with the shaft at the seventeenth year; the great trochanter and the head of the femur a year later; the condylar epiphysis ossifies with the femur soon after the twentieth year.

REMARKS.—The depression for the *ligamentum teres* varies greatly in size. Generally of a triangular form, it is often irregularly rounded, with swollen, everted lips; its size is greater, other things being equal, in young than in adult bones; and it is more acutely depressed in large massive specimens than in smaller and thinner ones. In the former, the lower lip is often thickened and thrown forward.—In certain specimens from females the depression is very shallow, and the foramina at the bottom are generally present. Sometimes reduced to one — often numerous and larger—they are well seen in young adult bones; but faintly marked, or entirely absent in oldish, or heavy massive ones. In arthritis, the depression is either entirely filled up, and even produced, or it is scooped out, and bears osteophytes upon its borders. The shape of the head varies.

The proximal end of the line of insertion of the Gluteus Maximus is often more pronounced than the remaining portion; when exaggerated in size, this prominence has received the name of the *third trochanter*, from the fact that it is analogous to a similar projection on the femur of some of the lower animals, such as the horse and the rhinoceros.—The epiphyseal line at the head lies within the embrace of the capsule. In some diseases of the femur, as, for example, inflammation at the head of the bone in coxalgia, the epiphysis may become detached.—The distal epiphysis may be detached by violence, and thereby simulate compound fracture of the lower third of the shaft.—An exostosis of the femur occasionally occurs by ossification of the tendinous insertion of the Adductor Magnus.—An exostosis from the posterior surface of the femur at its lower end has been known to rupture the popliteal artery and necessitate amputation of the thigh.[1]—An exostosis upon the inner side of the femur at the middle third is supposed to be caused by the frequent pressure of the thigh against the side of the horse in riding, and has from this circumstance received the name of *dragoon's exostosis.*

[1] Boling, N. A. Med. Chir. Rev., 1857, 608.

Necrosis of the femur is more frequent at the lower third of the shaft than elsewhere, particularly in the adolescent. This frequency is probably connected with the great vascularity of this portion of the bone during development.

THE TIBIA.

The tibia (figs. 1, 2, 3, Plate XXXIV.) is the largest of the long bones, the femur alone excepted. The shaft is for the most part prismoidal in form, narrower at the lower third than elsewhere, and presents a well-marked irregular expansion above to constitute the upper, and a smaller but decided increase of width below to constitute the lower extremity. The limits of the extremities are not, however, accurately distinguished from those of the shaft.

The tibia articulates by its lateral surfaces with the fibula at both the upper and the lower end. Above, the tibia is in articulation with the femur, and below, with the astragalus.

The *upper extremity* is expanded and elongated transversely, so that the borders project beyond the shaft, the median projection being the larger of the two. Above are seen two articular facets, the *condyloid* (glenoid) *surfaces*, for the femoral condyles. Each of their surfaces is of an oval shape, the internal being the more elliptical of the two. Between them is seen the *spine* of the tibia placed nearer the posterior than the anterior margin of the bone, and presenting two lateral *tubercles*, each of which is continuous with the curve of its own articular surface,—the median *internal* tubercle being the larger. Between the spine and the anterior border on the one hand, and the spine and the posterior border on the other, are two rough triangular surfaces for ligamentous attachment; the posterior of these is the more oblique, and is designed for the attachment of the posterior crucial ligament; the anterior is for the attachment of the anterior crucial ligament and the semilunar cartilage. The lateral surfaces of the upper extremity of the bone form the *tuberosities*. These are smooth, convex prominences, the median being the larger, and marked behind by a depression for the middle division of the tendon of the Semimembranosus muscle. The lateral tuberosity is broader than the median, and is further distinguished by a flat rounded facet directed downward and backward for articulation with the facet on the head of the fibula. In front a *tubercle* is situated for the origin of the Tibialis Anticus muscle. Posteriorly the upper extremity is slightly depressed, and exhibits between the articular surfaces the *popliteal notch* (inter-

condyloid notch). Anteriorly lies a smooth triangular surface whose apex is directed downward, and whose base lies a little backward therefrom on a level with the articular facets. This space is furnished with numerous vascular foramina, and in life is covered with a thick cushion of tough fatty tissue. At the apex the surface is provided with the roughened *tubercle for the attachment of the ligamentum patellæ.* Immediately above the tubercle the bone is smooth for the accommodation of a bursa.

The *shaft* of the tibia is broad above, but gradually narrows at its lower third, from which point of narrowing it slightly increases in size to the lower extremity. It presents an anterior, a lateral, and a posterior surface, and three borders of the same name.

The *anterior surface* is smooth, and, for the most part, slightly convex. At its upper third it receives the aponeurosis made up of the expanded tendons of the Sartorius, the Gracilis, and the Semimembranosus muscles. The middle third is smooth and subcutaneous, and forms the "shin" of common language. The lower third is slightly depressed if not concave; it is in part subcutaneous, and in part covered by the tendons of the extensors of the toes.

The *lateral surface* is concave for the upper two-thirds, somewhat convex at the lower third. It is furnished throughout its entire length with a *ridge* for the attachment of the interosseous membrane. The ridge lies near the posterior border, if, indeed, for the lower two-thirds of its length it does not define it, and is especially well marked at the lower end of the shaft, where it is the frequent site of small, irregular outgrowths. In front of this ridge, at its upper part, is a broad, shallow depression for the origin of the Tibialis Anticus muscle.

The *posterior surface*, the least regular of the three, is flat above, where it is marked by an *oblique line* which passes from the upper and the outer border downward and inward to terminate at the median border of the shaft at the junction of the upper and the middle thirds. It serves for the origin of the Popliteus muscle. The surface above the oblique line is covered by the last-named muscle; that below the line, as far as the position of the downward-directed *nutrient foramen*, by the origin of the Soleus muscle. Passing thence down the middle third of the bone is a vertical *ridge* (becoming indistinct below) which serves to separate the origin of the Flexor Longus Digitorum from that of the Tibialis Posticus muscle.

Of the *borders* of the tibia, the *anterior* is prominent at its upper two-thirds (crest of the tibia), but rounded and inconspicuous at its lower third. It is slightly curved outward at its upper third. It separates the anterior from the lateral surfaces. The *lateral border* is rounded and faintly expressed below the external tuberosity by a rounded surface. At the lower extremity it is more compressed, and answers to the ridge for the interosseous membrane. It separates the lateral from the posterior surface. The *posterior border* is well developed at its lower two-thirds, and is continuous above with the oblique line. In the upper third the border is smooth and rounded. It separates the anterior from the posterior surface.

The *lower extremity* is subtriangular in form, presents a base directed downward, and is furnished with swollen borders before and behind that project beyond those of the distal *articular surface.* The *anterior border* is for the most part smooth, but provided near the articular surface with a rounded eminence for the attachment of the anterior tibiofibular ligament. The *posterior border* is slightly smaller, and projects a little further downward than the foregoing. It is marked by a deep oblique *groove* (overlying the posterior surface of the internal malleolus) for the tendons of the Tibialis Posticus and the Flexor Longus Digitorum muscles. A fainter and less constant groove lying to the lateral side of the foregoing is designed to accommodate the tendon of the Flexor Longus Pollicis muscle. The *lateral surface* of the lower extremity is concave, and presents a small facet for articulation with the fibula; the *median surface* projects downward as a robust process, wider behind than in front—to form the *internal malleolus.* The *under surface* of the malleolus is smooth for attachment of the deltoid ligament. The distal articular surface of the tibia is broad, triangular, with its base directed laterally, its apex medianly, at which point it is abruptly deflected downward to form the lateral surface of the internal malleolus.

STRUCTURE.—At the *proximal end* of the tibia are seen two sets of nearly vertical lines passing from the condylar surfaces downward to the sides of the shaft. In the space between these, weak interlacing oblique lines, as well as others that terminate upon the sides of the spine above and the median aspects of the condylar lines below, are detected. Arranged horizontally to both the foregoing are simple, nearly concave lines which are sparsely distributed below the articular surfaces, and are in a measure concentric therewith.

In some specimens the lines of the epiphysis can be easily distinguished from those of the shaft. All the lines on the median half are stouter than those on the lateral.

At the distal end substantially the same arrangement exists as in the radius and ulna. Langerhaus describes the cancelli as made of a series of lines arranged either vertically to the articular surface or slightly converging to it; they are intersected by weak transverse lines. The arrangement varies in detail in the internal malleolus, as contrasted with the proper axial articular surface of the bone. The details of the epiphysis are measurably distinct from those of the shaft.

DEVELOPMENT.—The tibia arises from three centres of ossification. One for the shaft, which appears at the fifth or seventh week. One for the upper epiphysis at the ninth month of fœtal life. One for the lower epiphysis at the second year. The last joins the shaft at the twentieth year, and the first at the twenty-fifth. The tubercle very rarely arises from a centre of ossification separate from the proximal epiphysis.

When the shaft of the tibia is much compressed from side to side, as occurs in some savage and primitive races of men, it receives the name of the flat or platecnemic tibia.—The upper articular surfaces are sometimes placed obliquely to the axis of the shaft in such wise as to present the median surface on a higher plane than the lateral. This disposition of parts is commonly if not always found in limbs in which the position of extreme flexion has been maintained for a long time—In chronic rheumatoid arthritis the spaces behind and in front of the tibial spine are obliterated by new bony growths.

REMARKS.—Separation of the epiphysis of the distal[1] end of the tibia has been observed by R. W. Smith and R. Quain in lads sixteen and seventeen years of age. In this condition the internal malleolus will preserve its natural relations to the foot, but not to the leg or outer ankle. M. De Morgan[2] records a case of detachment of the tubercle of the tibia by muscular action in a boy of seventeen years. Deep-seated abscess of the bone is relatively frequent at about the junction of the upper portion of the bone with the shaft.—The tibia is liable to extraordinary deformation in rickets, owing to the fact that the resistance of the weight of the body is to a great degree transferred to it from the foot.—Exostoses may arise from the points of origin and insertion of muscles at the upper third of the bone.—From its peculiarly exposed situation, the anterior surface of the middle third of the shaft is a frequent seat of the changes incident to chronic ostitis and necrosis.

[1] British Med. Journ., Aug. 1867, 123.

[2] Med. Times and Gazette, 1853, 268.

THE FIBULA.

The fibula (figs. 4, 5, Plate XXXIV.) is a long slender bone placed to the outer side of the tibia with which it is in articulation at its two extremities. Below it joins the astragalus at the outer side. Its position as compared with that of the tibia is slightly oblique from above downward and forward. It is slightly twisted inferiorly. The inferior extremity is thus placed a little in advance of the upper, at the same time that the lower half is directed inward toward the tibia.

The fibula consists of a shaft and an upper and a lower extremity.

The *upper extremity* consists of a head, a neck, and a styloid process. The *head* is a rounded prominence exhibiting an oblique proximal surface directed downward and inward, and is distinguished by an oval *facet* (often inconspicuous) for articulation with the tibia. Laterally and posteriorly the head is subcutaneous in part. Along its free surface the Soleus and Peroneus Longus muscles arise. Behind the superior posterior tibio-fibular ligament is attached, and in front the superior anterior tibio-fibular ligament. The *neck* is a term conventionally applied to that portion of the shaft immediately below the head. Strictly speaking, it has no limitation. The *styloid process* of the fibula is directed proximally along the lateral side of the bone, and is designed for the attachment of the tendon of the Biceps muscle, and the short external lateral ligament of the knee-joint.

The *shaft* of the fibula is slender and more robust in the middle third than elsewhere. It is prismoidal and somewhat triangular in its upper two-thirds; irregularly lozenge-shaped in its middle third, and elliptical in its lower third. The shaft presents for examination three borders, three surfaces, and the ridge for the interosseous membrane. The *anterior border* extends from near the head to the lower third in a sharp, straight, well-defined line. As it approaches the lower third of the bone, it inclines outward and bifurcates, the inner branch of the bifurcation continuing as a straight line to the lower extremity, the outer diverging downward and outward to terminate on the outer surface of the external malleolus. The *external border* is more rounded than the anterior; it passes downward along the outer border to the lower third of the shaft, where it turns slightly backward to constitute the posterior border of the lower third. It

ends at the corresponding border of the external malleolus. The *internal border* is of less significance than the others. It is obscurely developed near the head; but about two inches below this part it assumes a linear appearance and continues hence to the lower third of the bone where it crosses the inner surface obliquely to terminate, as a rule, by joining *the ridge for the interosseous membrane.* This ridge begins near the head of the bone close to the inner side of the articular border, whence it continues downward along the inner surface to be lost above the articular surface of the external malleolus.—The *external surface* is concave at its upper two-thirds for the origin of the Peroneus Longus and the Peroneus Brevis muscles. It is smooth below and covered by the tendons of the same muscles. The *posterior surface* is flat for the origin of the Soleus muscle, and winds round the inner surface of the bone on its lower third, and is occasionally marked by a small *nutritious foramen* directed downward at about its middle third. The *internal surface* is divided by the ridge for the interosseous membrane into two narrow spaces, one lying between the ridge and the anterior border, yielding surfaces of origin for the Extensor Proprius Pollicis, the Extensor Communis Digitorum, and the Peroneus Tertius muscles, and the one lying between the ridge and the posterior border, wider and more depressed, designed for the origin of the Tibialis Posticus muscle.

The *lower extremity* answers to the lower twisted portion of the bone. It begins at the point of greatest lateral compression, namely, where the internal border joins the ridge for the interosseous membrane. Beyond, the narrow elliptical portion has received, from some English writers, the name of the neck. The inner side is rough and marked by an elongated triangular surface for the strong fibres of the interosseous membrane. The outer surface is convex and subcutaneous.

The lower extremity gradually increases in size as it approaches the corresponding extremity of the tibia where its distal end is called the *external malleolus.* Larger and more prominent than the internal malleolus, and, in articulation, placed a little posterior to it, the external malleolus resembles the lower third of the shaft, with which it is continuous in its wide lateral, and narrow antero-posterior surfaces. It is of a triangular shape, its antero-inferior border being somewhat angulated. The posterior border is thicker than the anterior, and is faintly grooved for the tendons of the Peroneus Longus and the Peroneus Brevis muscles. The *anterior surface* is convex and subcutaneous. The *median surface* presents a triangular articular facet, slightly convex from above downward for articulation with the astragalus, and at its upper portion with the tibia. Below and behind this facet is a roughened depression for the posterior fascicle of the external lateral ligament and the posterior fibres of the capsule. The summit is rounded for attachment of the middle fascicle of the external lateral ligament of the ankle-joint.

Structure.—In the proximal end the main lines of the cancelli radiate from the articular surface and are intersected by concave transverse lines. Substantially the same arrangement obtains at the distal end, where the radiating fibres are notably conspicuous, and where they pertain more to the surface of contact with the astragalus than with the tibia.

Development.—The fibula arises from three centres of ossification: One for the shaft which appears at the sixth week; one for the lower extremity which appears at the second year; and one for the upper extremity which appears at about the fourth year. The second named unites with the shaft at about the twentieth year, and the last at about the twenty-fifth.

Remarks.—The fibula and tibia when seen in articulation present some striking features of contrast. Thus the shaft of the tibia is turned slightly forward, while that of the fibula is turned backward and outward. The shaft of the tibia is prismoidal with the base directed backward; the shaft of the fibula is prismoidal with the base directed outward. The tibia extends proximally one inch beyond the fibula; the fibula extends distally one inch beyond the tibia. The lower third of the tibia is slightly compressed from before backward; the lower third of the fibula is greatly compressed laterally.

The most superficial parts of the fibula are the head and the lower third of the shaft including the malleolus.—The head of the fibula lies on a level with the tubercle for the Quadriceps Extensor tendon. This becomes a valuable point for reference in conditions where the head is concealed by swelling of the surrounding soft parts. The lower third of the shaft together with the malleolus can always be defined beneath the skin, and owing to its peculiarly exposed position is liable to fracture.

The place of insertion of the Biceps muscle sometimes forms a conspicuous rounded projection at the base of the styloid process.

The probable communication between the articular surface of the proximal end of the fibula and the knee-joint, as well as the proximity of important vessels

thereto, should be constantly borne in mind by the surgeon. It is asserted by Knox that an operation of Liston's for excision of this portion of the bone resulted in death from hemorrhage. Examples are on record of death from pyarthrosis following the same operation, as well as from the removal of tumors involving the head of the fibula.

In talipes varus the fibula may touch the calcaneum and effect a joint therewith. In atrophy of the peroneal muscles, notably that of the Peroneus Longus, the eminence of the external malleolus becomes unduly prominent.—Osteophytes are specially liable to form at the median margin of the shaft above the distal articular surface.

The mechanism of the deformity of fracture of both malleoli is, according to Dr. Gordon Buck,[1] as follows: When both malleoli are fractured, the tibia tends to slide forward so that only the posterior half of the articular surface rests upon the articular surface of the astragalus. The dorsum of the foot is hereby shortened and the heel projects backward. The lower part of the leg presents a remarkable curve with its convexity forward. The same authority[2] describes a specimen of necrosis of the tibia, in a child twelve years of age, in which a sequestrum extended through the distal end of the tibia into the ankle-joint, which was anchylosed. The specimen was mainly interesting from the circumstance that the process of necrosis was not limited to the compact portion of the bone, but had fairly extended into the spongy portion.

THE PATELLA.

The patella (figs. 6, 7, Plate XXXIV.) or knee-cap is a sesamoid bone lodged in the tendon of the Quadriceps Extensor Cruris muscle. It is subcutaneous, and can be easily distinguished in the undissected subject. It is movable when the leg is extended, but fixed against the trochlea and external condyle of the femur when the leg is flexed. It is broader than long, sub-triangular in form with its thickened rugose base directed proximally to receive the tendon of the Quadriceps. The apex is in connection with the ligamentum patellæ.

[1] N. Y. Med. Journ., iii., 1866, 41. [2] Ibid., 44.

The patella presents for examination an anterior and a posterior surface, and a median and a lateral border. The *anterior surface* is faintly convex in all directions, and is marked with linear striæ and grooves, as well as with a few nutritious foramina. The *posterior surface* is concave from above downward, and concavo-convex from side to side. It is covered with cartilage for articulation with the femur. A ridge-like eminence extends a little to the median side of the middle line downward and inward. The lateral facet is concave, and larger than the median, which is obscurely convex. The borders are slightly emarginated superiorly, but convex inferiorly. The apex of the bone projects downward to a distance equalling nearly one-fourth the length of the articular surface. The base of the patella is broader behind than in front. The lateral margin is thin and subtruncate; the median is evenly rounded.

Structure.—The patella, when sawn open from side to side, shows an evenly textured surface. The cancelli are small, save at the apex, where they are coarse and uneven.

Development.—The patella arises by a single centre of ossification, which appears at the third month.

Remarks.—The most important fact to be remembered in connection with the patella is its disposition to transverse fracture. This occurs either from muscular violence, or from falls upon the flexed knee when the patella is fixed against the patellar groove of the femur and the external condyle.

The Quadriceps muscle, by drawing the upper fragment away from the lower, creates a deep transverse sulcus. In place of a depression an elevation of the interosseous space may occur, an effect attributed by Jonathan Hutchinson[1] to the outward pres-

[1] Med. Chir. Trans., lii. 340.

EXPLANATION OF PLATE XXXIV.

Fig. 1. The tibia, seen from in front.
Fig. 2. The tibia, seen from the lateral side.
Fig. 3. The tibia, seen from behind.
Fig. 4. The fibula, seen from the median side.
Fig. 5. The fibula, seen from the lateral side.
Fig. 6. The patella, seen from in front.
Fig. 7. The patella, seen from behind.

PLATE XXXIV

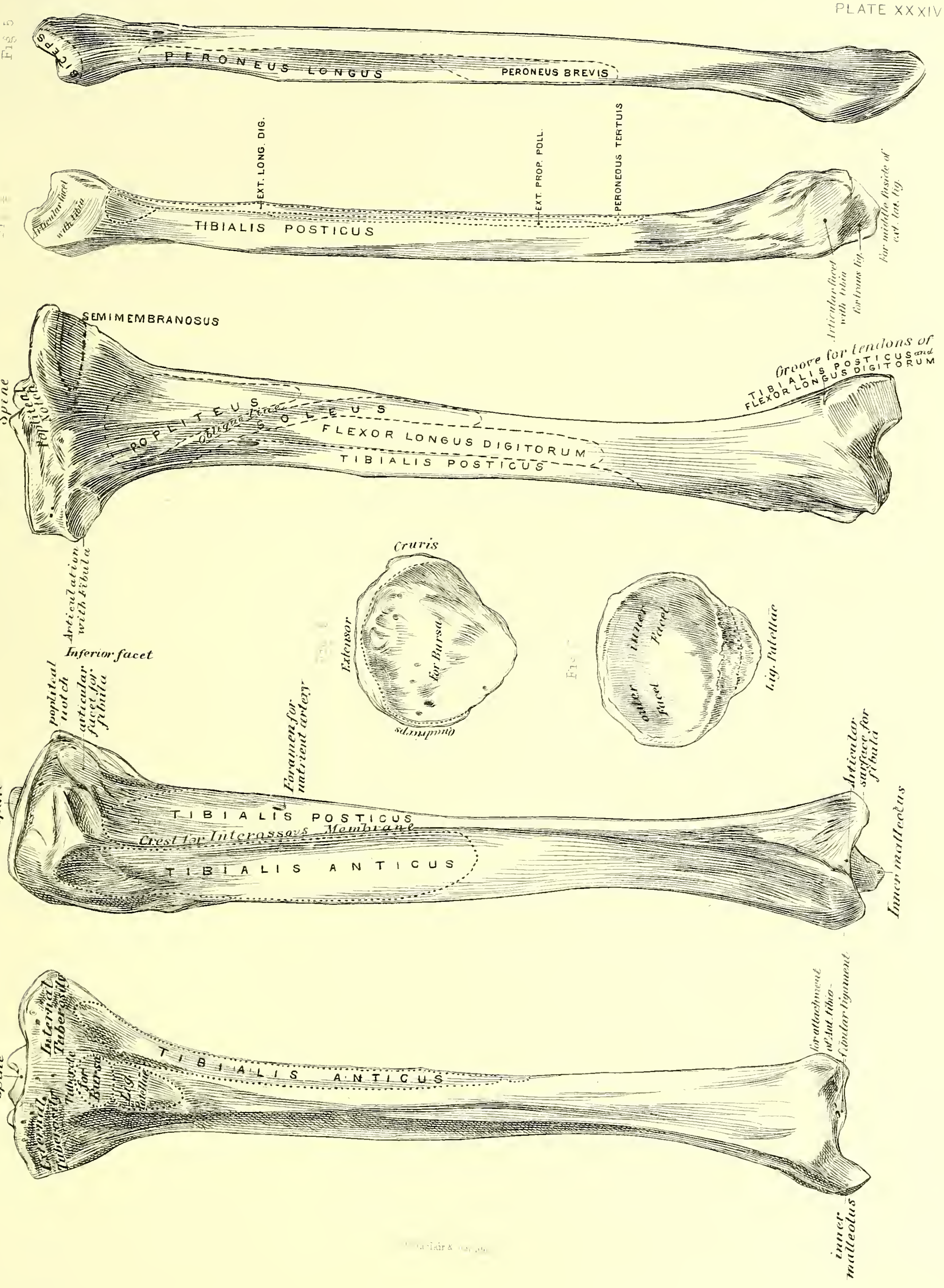


Fig. 5
BICEPS
PERONEUS LONGUS
PERONEUS BREVIS
Fig. 4
EXT. LONG. DIG.
EXT. PROP. POLL.
PERONEOUS TERTUIS
Articular facet with tibia
TIBIALIS POSTICUS
Articular facet with tibia
For trans lig.
For middle fasciculus of ext. lat. lig.
Fig. 3
SEMIMEMBRANOSUS
Spine
Popliteal Notch
POPLITEUS
Oblique Line
SOLEUS
FLEXOR LONGUS DIGITORUM
TIBIALIS POSTICUS
Groove for tendons of TIBIALIS POSTICUS and FLEXOR LONGUS DIGITORUM
Articulation with Fibula
Cruris
Extensor
for Bursa
Quadriceps
Inner Facet
outer facet
Lig. Patellae
Inferior facet
Fig. 2
popliteal notch
articular facet for fibula
Foramen for nutrient artery
Spine
TIBIALIS POSTICUS
Crest for Interosseus Membrane
TIBIALIS ANTICUS
Articular surface for fibula
Inner malleolus
Fig. 1
Spine
Internal Tuberosity
External Tuberosity
Tubercle for Bursa
Lig. Patellae
TIBIALIS ANTICUS
for attachment of Ant. tibio-fibular ligament
inner malleolus

sure of the synovial fluid of the joint. Union is almost always fibrous. Indeed, according to D. Hayes Agnew,[1] such a union is to be desired, since a true osseous union is liable to be destroyed.

The Bones of the Foot.

The bones of the foot (Plate XXXV.) are composed of the calcaneum, the astragalus, the cuboid bone, the scaphoid bone, and the three cuneiform bones, composing the *tarsus;* of the first, second, third, fourth, and fifth metatarsal bones, composing the *metatarsus;* and of the two toe-bones of the first toe and the three toe-bones in each of the remaining toes, that collectively constitute the *phalanges of the foot.*

THE TARSUS.

The Calcaneum.—The calcaneum (os calcis) is the largest bone of the tarsus, and constitutes the posterior abutment of the longitudinal arch of the foot. The shape of the bone is that of an elongated cube whose upper surface is irregularly depressed, and whose median surface is concave. The calcaneum articulates above with the astragalus, and in front with the cuboid bone. The bone is composed of a body and an anterior process. The *body* comprises the bulk of the bone, namely, the portion answering to the surface of articulation with the astragalus and the laterally compressed mass projecting backward from it to form the "heel." The *anterior process* is that portion of the calcaneum lying in front of the articulating surface for the astragalus, and it serves to articulate with the cuboid bone.—An imaginary line, passing round the heel directly behind the posterior margin of the ankle, indicates the so-called "neck" of the calcaneum.

In a more exact manner the calcaneum is described by its surfaces; these are six in number, as follows:—

The *superior surface* is divided into a posterior concave roughened surface which is free, and an anterior smooth surface for articulation with the astragalus. The last named is again divided into an anterior and a posterior portion, with an intervening depression. The anterior portion is elongated, concave, with sinuate margins; in front, as it overhangs the cuboidal face, a separate surface is often developed. The posterior portion is larger than the anterior, is sub-rounded, and looks downward and outward. It is supported by the stout process which has received the name of the *sustentaculum tali.* The depression between the two portions is narrow within, broad without, and yields attachment for the interosseous calcaneo-astragaloid ligament. When the calcaneum is in articulation with the astragalus, this depression is converted into a canal.—The *inferior surface* is narrowed from behind forward, and is marked at its posterior third by two tubercles named from their relative positions the median and the lateral *tubercle*, the former of which is much the larger. Probably the lateral tubercle sustains little or none of the weight of the body, since it is of merely muscular significance. It forms a round projection when seen from the lateral surface of the bone. Both tubercles afford points of attachment for the corresponding divisions of the plantar fascia, while the interval between them yields a surface of origin for the Flexor Brevis Digitorum. In front, on the median margin of the inferior surface, is a broad, slightly convex surface for attachment of the stout greater inferior calcaneo-cuboid ligament. The mechanical axis of the inferior surface of the calcaneum appears to lie obliquely to the *anterior tubercle*, for the attachment of the lesser inferior calcaneo-scaphoid ligament, inward and backward to the median tubercle, thus placing the lateral tubercle paraxially.—The *lateral* (external) *surface* is nearly vertical, and marked with numerous openings for bloodvessels. Placed near its middle is a welk-like rugosity, which, from the circumstance that it serves to separate the Peroneus Brevis from the Peroneus Longus muscle, is known as the *peroneal tubercle.* A second *tubercle* is situated near the cuboidal facet, and gives origin to the Abductor Minimi Digiti. In articulation it is a guide to the position of the calcaneo-cuboid joint.—The *median* (internal) *surface* (hollow of the calcaneum) is concave for the protection of the tendons of the posterior tibial muscles, and the plantar bloodvessels. The Flexor Longus Pollicis tendon lies in the best defined groove of the bone on the under surface of the *sustentaculum tali.*—The *anterior surface* is lozenge-shaped; the upper three-fourths of the space is occupied by an articular surface for the cuboid bone, and is triangular in form, the apex being directed upward. The facet is slightly convex laterally, but is concave medianly to form at the upper margin a conjunction with the astragalar articular surface. The lower angle of the anterior surface is roughened for the attachment of the inferior calcaneo-scaphoid ligament.—The *posterior surface* (calcaneal tuberosity, tuber calcis) is blunt and free. The upper portion inclines forward, and is covered with a bursa; the lower is roughened for the insertion of the tendo Achillis.

[1] System of Surgery, i. 980.

STRUCTURE.—The calcaneum presents a stout layer of compact tissue beneath the posterior astragalar articular surface and the depression in front of it; a second at the inferior surface by the bone directly beneath the foregoing; a third in the *sustentaculum tali;* and a fourth, much weaker, at the cuboidal surface. Elsewhere the interior is cancellous, and is composed for the most part of beautiful curved lines arranged in two sets, one extending from the cuboidal surface to the tuberosity, and concave upward; and the other ranging from the posterior astragalar surface to the tuberosity, and concave downward. A third set of radiating laminæ passes from the depression for the calcaneo-astragaloid ligament forward to the cuboidal surface. The laminæ at the upper half of the bone are coarser than those at the lower half..

REMARKS.—In *talipes equinus* the calcaneum is slightly raised, and assumes an oblique position. The degree of the elevation is more apparent than real, and is, indeed, more marked in *equino-varus* than in true equinus. The bone may be in contact with the tibia behind. In *talipes varus* the calcaneum is drawn upward by the Gastrocnemius and Soleus muscles, and occupies a very oblique, almost vertical position, with a slight inclination inward. The calcaneum in the new-born child presents a smaller portion of the astragalar surface upon the outer aspect of the bone than in the adult.[1] The *sustentaculum tali* is enlarged in acquired *talipes valgus;* but is relatively small in *talipes varus.* Necrosis attacks the calcaneum with relative frequency. The centre of ossification has been lost by necrosis in a child aged three years, as in a case reported by Mr. Birkett.[2] Necrosis of the tibia of the corresponding side ensued.

Geo. Buchanan[3] reports a case of excision of the calcaneum.

THE ASTRAGALUS.—The astragalus is, next to the calcaneum, the largest bone in the tarsus. It is placed between the bones of the leg above, the calcaneum beneath, and the scaphoid bone in front. It is irregularly cubical in shape, and, as usually stated, is composed of a body, a head, and a neck. The *body* answers in a general way to the surfaces of contact with the bones of the leg and the calcaneum, as well as to those occupied by the ligaments attached to the astragalus. The *head* is a synonym for the articular surface for contact with the scaphoid bone and the inferior calcaneo-scaphoid ligament. The *neck* is the constriction between the body and the head. It is better defined laterally (where it is narrow and depressed) than medianly (where it is broad, and makes up part of the median border of the foot) or inferiorly (where, indeed, its line bisects the calcaneal articular surface.)

In a more exact manner the astragalus is said to be made up of six surfaces: the superior, the inferior, the anterior, the posterior, and the two lateral surfaces.

The *superior surface* is for the most part occupied by the large facet for articulation with the axial distal surface of the tibia. It is narrower behind than in front; concave near the centre, but convex toward the two sides, the lateral side being the wider. In advance of the facet the superior surface includes the depressed proximal aspect of the neck.—The *inferior surface* is very irregular, and embraces three facets and a deep groove. The posterior facet for the corresponding posterior facet of the calcaneum is concave, broader behind than in front. It is obliquely placed to the axis of the bone, and, with reference to this axis, is disposed in the main to the lateral side. In front lies a deep groove for the attachment of the interosseous astragalo-calcaneal ligament. The remaining facets are contiguous in front of the groove, and include the oval surface for articulation with the anterior calcaneal facet, and a small ribbon-shaped facet (the head in part) for articulation with the inferior calcaneo-scaphoid ligament.—The *anterior surface* (the head in part) is an oblong, convex surface, whose longest diameter lies nearly at a right angle to the axis of the bone, but with an inclination downward and inward. It articulates with the scaphoid bone.—The *posterior surface* is a roughened, narrow ledge intervening between the tibial and the calcaneal articular surfaces. It is grooved toward the median side for the tendon of the Flexor Longus Pollicis. This groove is a valuable sign by which the surgeon can identify the astragalus in backward dislocation of this bone.—The *median surface* (inner) is irregular, and inclined a little inward. It is marked above, where it joins the superior surface at an angle, by a pear-shaped articular facet, for articulation with the internal malleolus. The base is directed forward, and lies in advance of the lateral articular facet. Below and behind this facet is the roughened surface for the attachment of the deltoid ligament. The median surface forms a well-defined limitation to the

[1] Huetter, Langenbeck's Archiv, iv., 1863, 475.
[2] Trans. Path. Soc. Lond., vi., 1856, 288.
[3] Edinburgh Med. Journ., 1876, 869.

neck anteriorly.—The *lateral surface* (outer) is in great part occupied by a facet. This is of a triangular shape, whose convex base is proximal, and whose apex is directed slightly outward. In advance of the lateral surface is a depression for the anterior lateral ligament; while behind lies a groove for the posterior lateral ligament. In front of the facet the surface is directed obliquely outward and forward, to form the lateral boundary of the neck. At a corresponding point beneath is the notch for the interosseous ligament. Behind, is the edge of the surface articulating with the body of the calcaneum.

To ascertain the side to which the astragalus belongs, place the bone with the superior facet upward; the side on which the neck is least defined will indicate the side to which the bone belongs; or, the position being the same, the external malleolar facet will point toward the side to which the bone belongs.

Structure.—The borders of the neck, both above and below, present a little compact tissue; elsewhere the bone is spongy. The lines of the laminæ are arranged in four sets. The first is composed of those finely textured cancelli underlying the proximal articular surface, and composing the bulk of the body of the bones; the second, of those passing from the posterior calcaneal surface, to join the first group; the third, of those stout, coarse lines extending directly backward from the scaphoid articular surface (the head) through the neck, to end abruptly against the first; and the fourth, of those weak lines passing obliquely upward and backward from that portion of the head in articulation with the inferior calcaneo-scaphoid ligament. The astragalus is weakest at the neck, where alone the third set of laminæ exists; it is here that the bone is most frequently fractured.

Remarks.—The changes in the foot after excision of the astragalus, together with the lower end of the fibula, in an instance recorded by Erichsen,[1] were as follows: The foot was drawn up by the tendon of the Tibialis Anticus muscle, and was slightly everted, forming a variety of *talipes equinus.* In another case of excision[2] the patient was able to walk three months afterward. The malleoli necessarily rest upon the calcaneum or the scaphoid bone. It is probable that in time a new joint may be formed between them and the bones of the leg; or anchylosis may ensue, as was found to be the case by E. Bellamy.[3] The power of adduction and abduction, of the foot in this condition, would be greatly impaired; as would also be the motions of the medio-tarsal joint.—Notwithstanding the preservation of all important muscular attachments, any sudden or violent attempt to throw the weight of the body upon the affected foot is liable to induce backward dislocation of the foot; the only force present resisting this tendency being the released fibulo-calcaneal and tibio-calcaneal ligaments.—After a careful study of three subsequent histories of removal of the astragalus for dislocation, J. Tufnell[1] concludes that a useful foot, such as would enable a laboring man to earn a livelihood, is not to be expected.

Mr. Wm. MacCormac[2] thus describes the position of the astragalus after a fracture and dislocation of the bone, of two years' standing: "The neck of the astragalus was fractured, the detached head remaining connected with the scaphoid; while the larger portion, or body of the bone, was completely displaced from between the malleoli backward and inward with a species of double rotation, so that the superior articulating surface was almost vertical, looked inward and slightly backward, and had the tendon of the Flexor Longus Pollicis fixed to it. . . . . The internal malleolus had been fractured, and between it and the inner border of the astragalus lay the tendons of the Tibialis Posticus and Flexor Longus Digitorum muscles."

The same author describes a second case thus: "The tibial surface was superficial, looking inward and slightly upward; the posterior extremity was directed downward toward the os calcis. Reduction could not be effected. The limb thirteen years afterward still exhibited the deformity as described. The man had very considerable movement in the ankle, and a slight degree of lameness was alone present."

In congenital *talipes varus* the shape of the astragalus is materially modified. The neck is longer than usual, and is more obliquely placed from without inward than in the normal bone. The head, in addition to its articulation with the scaphoid toward the inner border of the foot, is in part free beneath the skin of the dorsum of the foot. The superior articular surface at the ankle extends quite to the posterior edge of the bone, and is thin and wedge-shaped, instead of being obtusely rounded. The groove for the Flexor Longus Pollicis is absent.

In *talipes equinus* the astragalus inclines forward, in which direction it may be partially dislocated. In

[1] Med. Times and Gaz., Mar. 1860, 317.
[2] Med. Times and Gaz., Mar. 20, 1860.
[3] Trans. Path. Soc. Lond., 1873, 172.

[1] Dublin Medical Press, Dec. 28, 1853.
[2] Trans. Path. Soc. of Lond., 1875, 174.

talipes valgus, either congenital or acquired, the head of the bone can be easily defined under the skin, owing to the relaxed condition of the ligaments. The inner border of the head is very prominent.

Hueter has pointed out the fact that the neck of the astragalus in the infant is relatively longer than in the adult, and presents a nearly transverse scaphoid articular surface.

The astragalus is the only bone in the tarsus without muscular attachment.

THE CUBOID BONE.—The cuboid bone is of an irregular cuboidal figure, broader behind than in front, and verging to the pyramidal form, since all its surfaces, excepting the median, slope toward the compressed lateral border. It is situated to the outer side of the foot, with the calcaneum behind, the fourth and fifth metatarsal bones in front, and the external cuneiform and scaphoid bone to the median side. It presents six surfaces for examination. The *superior* surface is smooth, and covered by the Flexor Brevis Digitorum. The *inferior* (plantar) *surface* is grooved obliquely for the tendon of the Peroneus Longus; behind the groove is a broad tubercle for the attachment of the greater inferior calcaneo-cuboid ligament. At the proximo-median angle is a rugosity for the attachment of the lesser inferior calcaneo-cuboid ligament. The *lateral surface* is grooved obliquely for the Peroneus Longus muscle prior to its entering the plantar groove. The *median surface* is flat, and marked with an oval facet for articulation with the external cuneiform bone, and commonly by a facet contiguous with the foregoing for the scaphoid bone. It is also roughened for the attachment of ligaments. The *distal surface* is subtriangular, and divided by a vertical ridge into two facets for the articulation of the fourth and the fifth metatarsal bones. The *proximal surface* is concave vertically, and convex from side to side to articulate with the calcaneum. Holding the bone with the grooved under surface downward, and the concave articular surface backward, the compressed border marked by the groove for the Peroneus Longus muscle will point to the side to which the bone belongs.

THE SCAPHOID BONE.—The scaphoid or navicular bone is placed on the inner side of the foot, having the astragalus behind it, the cuneiform bones in front, and the cuboid bone to the lateral side. It is compressed from behind forward, thicker below than above, and slightly inclined from beneath upward and outward. Above, the *proximal surface* is concave and pear-shaped, for articulation for the most part with the head of the astragalus. The *anterior surface* is curved transversely, and divided by two faintly marked, diverging ridges, defining three facets for articulation with the corresponding cuneiform bones. The *median surface* is broad, free, and somewhat roughened for the attachment of ligaments. The *lateral surface* is compressed, and commonly presents an uneven surface for articulation with the cuboid bone. The *inferior surface* is for the most part occupied by a pronounced *tuberosity* for the insertion in part of the Tibialis Posticus muscle. To the outer side of this prominence lies a narrow surface for the attachment of the inferior calcaneo-scaphoid ligament. According to Cruveilhier, the tuberosity may be greatly enlarged, and has been mistaken for an exostosis. It serves as a guide to the astragalo-scaphoid articulation. Holding the bone with the concave surface toward the observer, and the thickened end down, the narrow, roughened, lateral surface will point toward the side to which the bone belongs.

REMARKS.—In pronounced *talipes varus* the tuberosity is in contact with the inner malleolus. The long axis of the bone is parallel with the long axis of the leg, instead of being at right angles to it. In *talipes equinus*, the scaphoid is drawn somewhat toward the plantar surface.

THE CUNEIFORM BONES.—The three cuneiform bones are so named from the resemblance each bears to the figure of the wedge. They are lodged between

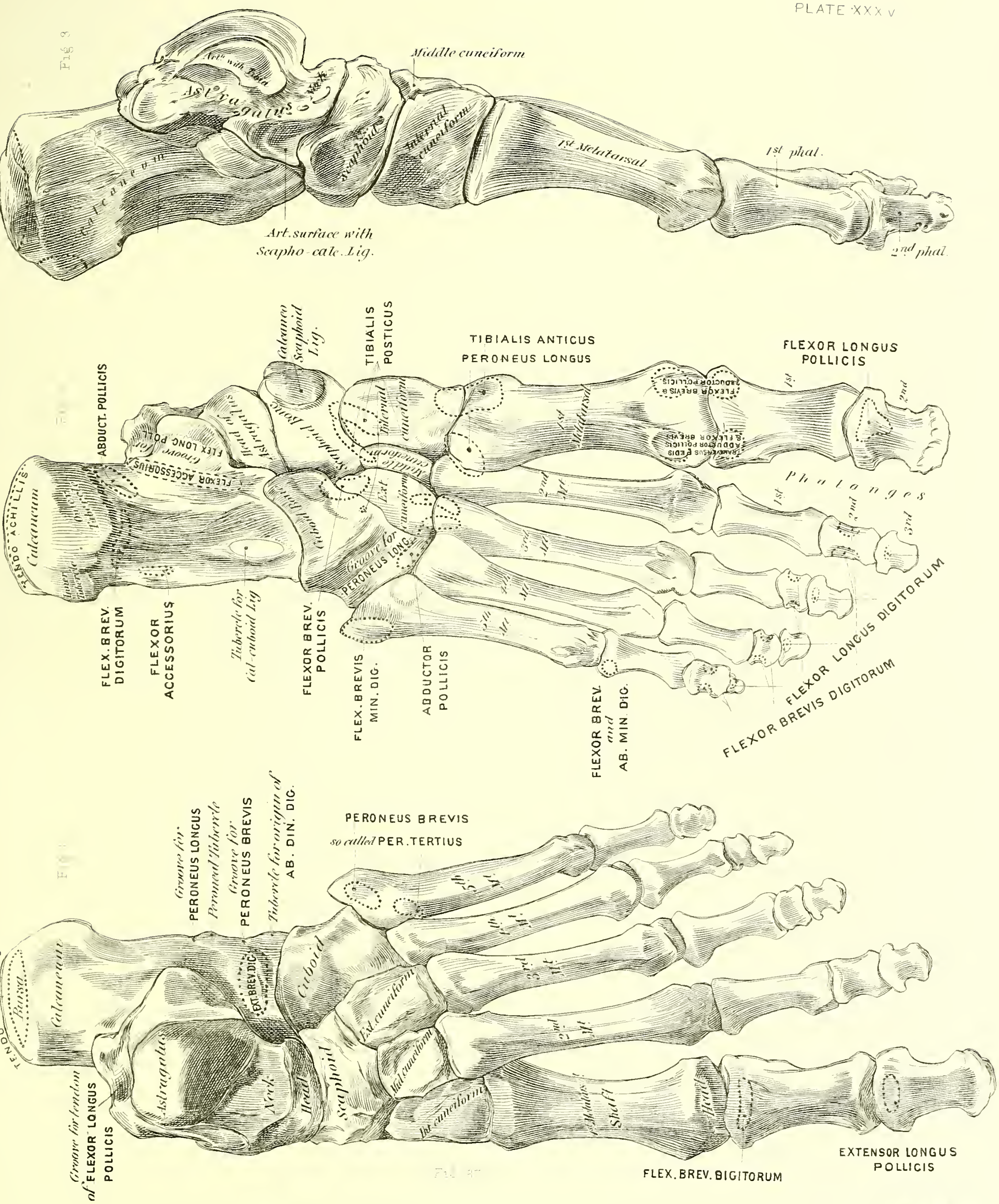
EXPLANATION OF PLATE XXXV.

Fig. 1. The bones of the foot in articulation, seen from above.

Fig. 2. The bones of the foot in articulation, seen from beneath.

Fig. 3. The bones of the foot in articulation, seen from the median side.

PLATE XXXV



Middle cuneiform
Art. with Tibia
Astragalus
Neck
Calcaneum
Scaphoid
Internal cuneiform
1st Metatarsal
1st phal.
2nd phal.
Art. surface with
Scapho-calc. Lig.
Calcaneo Scaphoid Lig.
TIBIALIS POSTICUS
TIBIALIS ANTICUS
PERONEUS LONGUS
FLEXOR LONGUS
POLLICIS
ABDUCT. POLLICIS
FLEX LONG POLL
FLEXOR ACCESSORIUS
TENDO ACHILLIS
Calcaneum
Scaphoid bone
Internal cuneiform
Middle cuneiform
Ext cuneiform
Cuboid
Groove for PERONEUS LONG.
1st Metatarsal
Phalanges
FLEXOR BREVIS & ABDUCTOR POLLICIS
ADDUCTOR POLLICIS & FLEXOR BREVIS
TRANSVERSUS PEDIS
FLEX. BREV. DIGITORUM
FLEXOR ACCESSORIUS
Tubercle for Cal-cuboid Lig.
FLEXOR BREV. POLLICIS
FLEX. BREVIS MIN. DIG.
ADDUCTOR POLLICIS
FLEXOR BREV. and AB. MIN DIG.
FLEXOR LONGUS DIGITORUM
FLEXOR BREVIS DIGITORUM
Groove for PERONEUS LONGUS
Peroneal Tubercle
Groove for PERONEUS BREVIS
Tubercle for origin of AB. DIN. DIG.
PERONEUS BREVIS
so called PER. TERTIUS
TENDO ACHILLIS
Bursa
Calcaneum
Cuboid
EXT. BREV. DIG.
Astragalus
Neck
Head
Scaphoid
Ext. cuneiform
Mid. cuneiform
1st cuneiform
Shaft
Head
Groove for tendon of FLEXOR LONGUS POLLICIS
FLEX. BREV. BIGITORUM
EXTENSOR LONGUS POLLICIS

the scaphoid bone behind, and the first, second, and third metatarsal bones, respectively, in front.

With the *internal* (first) *cuneiform* the form of the wedge is obscured by having the convex base directed downward. The sides of the bone being curved, and the apex irregular, the bone projects distally nearly one-half its length beyond the second. The median surface is free, roughened, unequally convex, and marked below by a smooth surface for the tendon of the Tibialis Anticus muscle. The lateral surface is concave, and for the most part is markedly roughened for the attachment of ligaments, but faceted above for articulation with the middle cuneiform bone and the second metatarsal bone. Its proximal surface is pear-shaped, and presents a concave articular surface whose base is directed downward for articulation with the scaphoid bone. Distally a kidney-shaped facet is seen, its notch lying to the outer side, for articulation with the first metatarsal bone. The upper portion of the bone is angulated, and is thicker before than behind. The inferior portion is free, and projects conspicuously below the plane of the other cuneiforms to form the *tuberosity* which receives the tendon and attachment of the Tibialis Posticus and a portion of the Tibialis Anticus muscles. Holding the bone with its large end downward, the notch in the anterior facet will point to the side to which the bone belongs.

The *middle* (second) *cuneiform*, the smallest of the three, resembles a wedge to a greater degree than does either of the other cuneiforms. It is quadrangular on the dorsal surface, slightly narrow toward the distal end, and tapers at the plantar surface to a thin edge. The distal surface, designed for articulation with the second metatarsal bone, is broader below than the proximal which articulates with the scaphoid bone. The median surface is faceted at the upper half and along the proximal margin for the first cuneiform bone. The lateral surface articulates posteriorly and superiorly with the external cuneiform. Holding the bone with the broad end upward and the smaller end forward, the side with the smaller facet will point to the side to which the bone belongs.

The *external* (third) *cuneiform* recalls the general shape of the preceding, but is readily distinguished therefrom by its greater size, and by retaining the axis of the proximal articular surface at an angle to that of the distal. The bone projects about one-fourth its length distally beyond the middle cuneiform. The distal facet for the third metatarsal bone is longer than the proximal for the scaphoid bone, which in its turn is oblique from without inward, and from behind forward, and concave beneath where it yields a roughened surface for the attachment of ligaments. Laterally the third cuneiform presents at the junction of the dorsal and proximal margins a facet for articulation with the cuboid bone, and occupies about one-fourth of the lateral surface. Occasionally it presents a small facet at the dorsal edge of the distal border for articulation with the fourth metatarsal bone. Medianly the bone is depressed in the centre, and presents a roughened surface with two facets; the proximal of which articulates with the middle cuneiform, and the distal with the second metatarsal bone. Holding the bone with the base upward and the oblique facet backward, the lateral surface will point to the side to which the bone belongs.

REMARKS.—Dislocation of the second and third cuneiform bones on the dorsum of the scaphoid is described by Hancock.[1] The bones were excised, and the patient, a boy fourteen years of age, recovered. The bones of the tarsus are exceedingly liable to caries. Direct injuries except those arising from crushing degrees of force are infrequent. Small exostoses are not rarely seen on the dorsal surface of the first cuneiform.

THE METATARSUS.

The metatarsal bones are five in number, arranged in a transverse arch between the row formed by the cuboid and the cuneiform bones behind, and the phalanges in front. Each bone consists of a shaft and of a distal and a proximal extremity. The shaft is of a prismoidal form, and is more or less compressed laterally. The distal surface is convex, and the proximal flat or slightly concave.

The metatarsal bones are divided into those articulating with the first, the second, and the third cuneiform bones, and those articulating with the cuboid, namely, the fourth and the fifth. In each of the former group a line drawn along the dorsum, from the middle of the distal surface, will pass through the middle of the proximal surface. In the latter a line drawn from the same point as above will be directed to the outer margin of the bone before reaching the proximal surface.—The *first* bone of the series is the most massive. Its proximal surface is kidney-shaped with the notch directed outward, and is placed at right angles to the longitudinal axis of the bone. The distal surface, while convex and smooth above, is marked below by a median ridge defining two grooves, one on either side, for articula-

[1] Anat. and Surg. of the Human Foot, 1873, 95.

tion with the sesamoid bones.—The *second* is the longest of the series. It possesses a slightly concave triangular proximal facet whose apex is directed downward. It presents a roughened, flattened tubercle on the lateral side for ligamentous attachment with the third metatarsal bone. On the same surface the articular surface is divided into two facets by a sulcus. —The *third* possesses a proximal, flat, triangular surface. The lateral surface for ligaments is convex. The articular facet on this side is somewhat triangular; the dorsal border is nearly straight; the groove beneath the single facet is well defined.—The *fourth* metatarsal presents a proximal articular surface which is triangular; its apical portion is depressed, so that the surface has the appearance of having two facets. The external facet for articulation with the fifth metatarsal is triangular, with a convex dorsal border; the groove is very well defined.—The *fifth* metatarsal bone possesses a compressed shaft whose proximal surface is flat or oblique. The median surface is large, with a small ridge on the proximal border, which is received within a groove upon the lateral surface of the fourth metatarsal. The lateral border is prolonged into a process proximally near the plantar surface, but separated from the articular surface by a groove.

Synoptical Table of the Metatarsal Bones.

- The axis of the dorsal aspect of the distal surface cuts the proximal surface of the first, the second, and the third metatarsal bones, as they articulate with the cuneiforms.
  - Without lateral facets, and possessing grooves for the sesamoid bones on the distal surface. The proximal surface is reniform, with its dorsal border arranged transversely to the longitudinal axis . . . . First.
  - With facets on either side of the proximal extremity . . . . Second, third, fourth.
    - The external lateral surface with faintly marked groove, and flattish tuberosity; proximal surface triangular, concave . . . . Second.
    - The external lateral surface with facet concave, dorsal border straight; the groove is narrow, defined; the tuberosity pronounced; proximal surface triangular and flattened . . . . Third.
- The axis of the dorsal aspect of the distal surface does not cut the proximal surface of the fourth and the fifth metatarsal bones as they articulate with the cuboid.
  - The lateral surface flat with convex dorsal borders; the groove deep, the tuberosity pronounced. The proximal surface triangular with apical third depressed . . . . Fourth.
  - The facet on proximal end on one side only (median), external tubercle large . . . . Fifth.

THE PHALANGES.

These agree with the characteristics of the corresponding bones of the hand to such a degree that little need be said in detail in this connection.

The most marked peculiarities are the following:—The phalanges of the first toe are relatively larger than the same bones of the hand, while those of the remaining toes are relatively smaller. The shafts of the bones, excluding those found in the great toe, are more compressed laterally. The phalanges of the fourth and fifth middle toes, as well as the first phalanx of the great toe, are apt to be deformed in the skeletons, as seen in our cabinets, by reason of the almost universal practice of wearing ill-fitting shoes.

The *sesamoid bones* are placed on each side of the plantar surface of the distal end of the first metatarsal bone. They are osseous developments within the tendons of the Flexor Brevis Pollicis. They are faceted on their dorsal, but are free and roughened on their plantar surfaces. They can be felt obscurely beneath the skin in the undissected subject.

THE FOOT.

When the bones of the foot are in articulation with each other an elongated figure results, which is narrow and compact behind; broad and spreading in front; convex above, but concave, irregular, or flat below.

The bones of the tarsus are arranged in rows, with the exception of the astragalus which overlies the calcaneum. The distal surfaces of both the last-named bones advance to nearly the same level, and form the proximal surfaces of the *medio-tarsal joint*, to which the scaphoid and the cuboid bones contribute the distal surfaces. The tarsal (in advance of the medio-tarsal line) and the metatarsal bones are more or less arched transversely (frontally). The *tarso-metatarsal joint* is curved forward, and the median end is advanced beyond the lateral. The proximal end of the second metatarsal bone is sunk in a depression called the *mortise*, between the first and the second metatarsal bones. The phalanges are arranged in a nearly flat series, and present proximal

surfaces on a single line, save the fifth alone, which is advanced proximally beyond that of the others.

Among the remaining parts defined by the union of the bones, but absent or not well seen in the isolated bones, may be mentioned the following:—

The canal that is formed between the astragalus and the calcaneum.

The oblique groove extending across the plantar surface from the lateral border of the cuboid bone, forward and inward; this is the *peroneal* (plantar) *groove* for the accommodation of the tendon of the Peroneus Longus muscle.

An eminence at the dorsal surfaces of the first and second cuneiform bones that has received the name of the *instep*.

The portion of the calcaneum projecting posteriorly to the astragalus and forming the "heel." Duchenne[1] describes the heel as the "arrière pied," as opposed to the foot in advance of the ankle, which he calls the "avant pied."

Interosseous spaces are formed between the metatarsal bones and the phalanges. Of these the space between the bones of the first and the second of the series is the widest.

The median border of the plantar surface is robust distally, and ends abruptly with the scaphoid proximally. The lateral border of the same surface is weak distally, but becomes increasingly robust proximally, to end in the enormous median plantar tubercle of the calcaneum.

The bones of the foot are arranged in two longitudinally disposed series—a median and a lateral. The *median* series is composed of the phalanges of the first, the second, and the third toes, and of the metatarsal and tarsal elements with which these articulate. The *lateral* series is composed of the fourth and fifth toes and of their respective metatarsal and tarsal bones. Seen in a tabular form the arrangement is easily followed.

A Table of the Bones of the Foot arranged in Longitudinal Series.

I.	II.	III.	IV.	V.
1st phalanx	1st phalanx	1st phalanx	1st phalanx	1st phalanx
2d phalanx	2d phalanx	2d phalanx	2d phalanx	2d phalanx
1st metatarsal	3d phalanx	3d phalanx	3d phalanx	3d phalanx
1st cuneiform	2d metatarsal	3d metatarsal	4th metatarsal	5th metatarsal
	2d cuneiform	3d cuneiform		
	Scaphoid		Cuboid	
	Astragalus		Calcaneum	

When the weight of the body rests upon the *flexed* lower extremity, and the heel is elevated, the tibia is inclined forward upon the widest portion of the superior articular surface of the astragalus; the greater part of the weight is thus transmitted through the last named bone to the *median series* of the foot as far as the metatarso-phalangeal joints, beneath which in the living subject is the callous pad, the ball of the toes. Along this line the articular surfaces of the bones are composed of proximal convexities resting within distal concavities—in a word, of a series of segments of balls resting within partial sockets. The weight is in part sustained by the plantar ligaments.—The *lateral series* in this position has but slight work to do, viz., to act as a crutch to the *median*.—When the weight of the body is borne by the *extended* lower extremity, the foot rests firmly on the ground, and the weight is in part transmitted from the astragalus to the calcaneum, and thence to the cuboid bone and the bones of the fourth and the fifth toes. The median series receives, however, much of the weight of the body by means of the head of the astragalus resting in this position in the concavity of the scaphoid bone, and on the inferior calcaneo-scaphoid ligament. The impress of the foot is greater on the lateral than on the median side.[1] According to F. O. Ward,[2] the attitude first described is employed to distribute the force of sudden concussion, as from a jump; the second posture is assumed when the foot is required to sustain some heavy continuous pressure, that of the trunk for instance, augmented, as it often is, by the addition of a ponderous burden.

[1] Physiologie des Mouvements.

[1] Boston Medical and Surgical Journal, xc. 48.

[2] Outlines of Osteology, 367.

The tarsal and the proximal ends of the metatarsal bones of the median series, excepting the astragalus, tend to form wedges (least pronounced in the scaphoid) whose bases are either dorsal or plantar; while those of the median series are wedges whose bases are lateral (least pronounced in the fourth metatarsal). The plantar surface of the median series is acutely arched at the tarsus and the metatarsus, while the plantar surface of the lateral series is flat. It is of interest to note that wounds of the lateral series are less severe than those of the median.

In addition to the disposition of the bones above noted, the foot, when studied as a separate mechanism, yields two principal arches—the longitudinal and transverse—which are arranged to sustain the weight of the body, and to protect the plantar nerves and bloodvessels. The *longitudinal arch* is not an exact figure, since it is composed of the oblique line extending from the ball of the foot to the summit of the astragalus, and thence, by an abrupt descent, to the external plantar tubercle of the calcaneum. The *transverse arch* is best defined at the medio-tarsal joint, between the plantar surface of the first cuneiform bone and the lateral border of the cuboid. Both the longitudinal and the transverse arches are subject to modification. The formation of the transverse arch depends upon the ability of the bones composing it to be accurately adjusted by pressure; upon the degree and the kind of motion permitted between the bones; upon the nature of the connecting ligaments, as well as the lines of traction of powerful muscles. When the arch is relieved from the strain of the weight of the body, it assumes a narrow and high position; but when it sustains the weight of the body, it tends to become flattened, and would be obliterated were it not for the weight forcing the lateral and the median ends of the arch to the sides, at the same time that the dorsal approximal angles of the bones are tilted toward each other. As the arch is thus retained, the ligaments and the tendons of muscles passing between the plantar surfaces and the corresponding surfaces of the other bones become tense and limit the degree of motion.

The muscles that sustain the arch are the Tibialis Anticus, the Tibialis Posticus, and the Peroneus Longus. When, apart from the condition of the bone, softening of the ligaments or paralysis of the muscles ensues, the efficacy of the arch is impaired, and may be destroyed. Flat foot and various pseudo-neuralgic conditions may result from such failure of action.

Development.—The tarsal bones ossify after the following method: Each arises from a separate centre, except the calcaneum, which retains an epiphyseal centre at the surface of attachment of the tendo Achillis. The calcaneum receives its bony nucleus at the sixth month; the astragalus at the seventh month; the cuboid at the ninth month; the third cuneiform at the first year; the internal cuneiform at the third year; and the scaphoid and middle cuneiform at the fourth year. The calcaneal epiphysis joins the body of the bone at the tenth year. Gruber[1] reports a case in which the portion of the astragalus accommodating the tendon of the Flexor Longus Pollicis existed as a distinct ossicle.

The metatarsal bones and the phalanges develop after the method of the similar parts in the hand. Each bone presents a single nucleus for the shaft or body, and one for an epiphysis. The epiphyseal nucleus is distal in the metatarsal bones from the second to the fifth, but is proximal in the first. The epiphyseal nucleus is proximal in all the phalanges. The order of ossification is as follows: In the metatarsal bones the nuclei of the shafts appear in the eighth or ninth week. The epiphyses appear from the third to the eighth year, and unite with the shafts from the eighteenth to the twentieth year. The nuclei of the shafts of the phalanges appear in the ninth or tenth week. The epiphyses appear from the eighth to the tenth year, and unite with the shafts from the nineteenth to the twenty-first year.[2]

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[1] Archiv. Anat., Physiol., und Wissensch. Medecin., 1864, 286.
[2] Quain's Anatomy.

THE JOINTS AND THE LIGAMENTS.

GENERAL CONSIDERATIONS.

Joints or articulations are those portions of the body which serve to hold the bones in their natural relations to one another. They assist the bones in supporting the soft parts of the body, and in resisting shock. They thus resemble the skeleton, with which division of anatomy some writers include them. In their simplest forms they are composed of capsules, ligaments, synovial membranes, fibro-cartilage, and the cartilaginous coverings of the ends of the bones. It follows that a description of a joint must be in part a repetition of the account of such surfaces of the bones as are apposed within the joints.

Ligaments are bundles of fibrous tissue that assist the joint surfaces in maintaining contact, and in limiting their ranges of motion. In all their functions they act in conjunction with muscles. They are flexible structures, and are attached to the bones they unite; they are often continuous with the periosteum, and are intimately incorporated with the origin and the insertion of muscles.

In the study of the joints it is assumed, as above mentioned, that the cartilaginous surfaces are retained upon the ends of the bones, and that they, together with the accessory parts, are inspected in the living condition.

The following are the definitions of terms used in the descriptions:—

A Ligament is that structure which unites two separate bones. It may be composed of fibrous or elastic tissue. Prominent folds of synovial membrane are for convenience also termed ligaments.

Ligaments exist either in the form of capsules or of separate bands or thongs.

A Capsular Ligament is a bag of fibrous tissue holding the apposed ends of bones together. It forms the foundation of the movable joint. It is uneven and fasciculated on the outside, but smooth on the inside, where it is covered with the synovial membrane.

Accessory Ligaments are those which aid in supporting the capsular ligament. The internal lateral ligament of the temporo-maxillary articulation is such a structure. Accessory ligaments may pass over large portions of a single bone, or over many bones.

Check Ligaments are those which limit the action of articular surfaces. The term is restricted by the older writers to a special ligament which limits the motion of the median atlo-axoid articulation. But in a more exact sense most of the ligaments about the joints of the limbs check undue motion of the articular surfaces. Thus the lateral ligaments of the joints between the phalanges check the lateral motion; the inferior calcaneo-scaphoid ligament checks the otherwise too free motion of the astragalus, etc. It follows that rupture of a check ligament will create dislocation.

A Facet is a portion of articular surface which is distinguished from adjacent portions of the same surface by difference of curvature. Thus the occipital condyle has two facets, the patella seven, the head of the astragalus four, etc.

Fibro-Cartilage is a tissue which has, as the name indicates, the properties of both fibrous tissue and cartilage. There are three varieties of fibro-cartilage —interosseous, interarticular, and circumferential.

Interosseous fibro-cartilage is found between the bodies of the vertebræ, or between the pubic bones. It is firmer at the periphery than elsewhere, and may con-

tain in the centre, as in the last-named example, a synovial sac.

Interarticular fibro-cartilage (meniscus) is found between articular surfaces, and divides the joint more or less perfectly into two compartments. The plate may extend entirely across the joint, as at the sterno-clavicular and temporo-maxillary articulations, in which forms it is apt to be thinned toward the centre; or it may be crescent-shaped, and fixed laterally to the capsule or ligaments of the joint, the remaining portion lying free in the joint, and covered with synovia on both sides.

Circumferential fibro-cartilage is the name given to bands at the edges of sockets of bone, which serve to deepen the sockets. Such, for example, are the cotyloid ligament of the hip bone, and the glenoid ligament of the shoulder-blade.

SYNOVIA is the fluid secreted by a synovial membrane. It is a transparent, alkaline, albuminate fluid, of glairy consistence, yellowish color, and saltish taste. A *synovial membrane* is a delicate structure allied to serous membrane, and lines the joint cavity. It sends occasional pockets or culs-de-sac among the accessory ligaments or adjacent muscles.

ON THE ACTION OF JOINTS.

A correct conception of the following subjects is demanded in studying joint-action: Atmospheric pressure, action of ligaments, presence of synovia, action of muscles, and the shapes of facets.

Atmospheric Pressure.—The pressure of the atmosphere upon a joint forces the cartilages against one another, and the more yielding soft parts inward from all sides. The tags of synovial membrane occupied by fat are by the same pressure driven into spaces in the joint unoccupied by cartilages or capsule. When a joint is filled with fluid, as for example serum or pus, or, as in the course of experimentation on the subject, with water or air, the contact between the bones is broken. Atmospheric pressure, therefore, as exerted upon a healthy joint, precludes the existence of a joint cavity in the proper sense of the term.

Atmospheric pressure is best studied in joints having wide range of motion. In the knee, for example, when the condyles of the tibia are resting upon the posterior portions of the condyles of the femur (that is to say, the joint being in the position of extreme flexion), the anterior parts of the joint are separated from one another, and the integument on either side of the patellar ligament is to be seen depressed: the weight of the atmosphere, it is thought, has pushed the superficial parts in to occupy the otherwise gaping interval in the front of the joint. The brothers Weber found that the hip-joint remained intact as long as the normal relations to the atmospheric pressure were maintained. But the moment an opening was made through the bottom of the acetabulum the femoral and acetabular surfaces spontaneously separated.

Action of Ligaments.—The ligaments assist in maintaining contact between joint surfaces, and in limiting the motion of articular surfaces.

Presence of Synovia.—Synovia lubricates the interior of the joint, and lessens friction.

Action of Muscles.—No theory of joint action is complete without a knowledge of the action of those muscles that either cross over joints, or have their attachments at or about them. Appropriate muscular action determines the normal lines of pressure and resistance, and indicates the direction of motion of the various parts of the joint in changing from a flexed to an extended position. In joints of simple construction muscles may take the place of accessory ligaments, as, for example, in the shoulder, where it is shown that paralysis of such muscles causes the head of the humerus to fall away from the glenoid cavity of the scapula. It is probable that muscular action may serve as a compensating force in maintaining contact between the articular surfaces when the ligaments are softened and relaxed by diseased action.

The Shapes of Facets.—As the distance of the articular surfaces from one another in the healthy joint is invariable, and the condition above named nominally present, the degree of muscular power required to cause the curve-like motions of the joints is not so great as would at first sight be supposed. The shapes of the joint surfaces assist the ligamentous or other checks in preventing too great latitude of motion. It is evident that the articular surface of the coronoid process of the ulna, for example, limits the degree of flexion of that bone upon the humerus, as the surface of the olecranon limits its extension. In like manner the entire ulno-humeral joint acts as a check to the radio-humeral rotatory motion, if indeed it does not convert it in the acts of flexion and extension from a rotatory to a ginglymoid joint. The slightly oblique path of movement of the humero-ulnar joint is checked by the direct path of movement of the radius on the humerus. In carnivorous animals, such as the badger, the motions of the temporo-maxillary joint are strictly confined by con-

spicuous processes, descending both in front and behind the temporal cavity to embrace the neck of the lower jaw so that the otherwise shallow socket is deepened. May not the significance of all forms of deep sockets depend upon the development of these retaining check processes? and may not the greater limitation of motion in the hip compared with that of the shoulder be due to the circumferential check surfaces of the former?

SUTURA.[1] Sutures are the common mode by which the bones of the cranium unite, and they are not seen in any other part of the adult skeleton. They are generally described as being of four kinds, as follows: *The harmonic suture.* This is defined where two nearly smooth surfaces are opposed. The irregularity of many parts of the harmonic suture gives the clue to the significance of the remaining three. Examples are seen between the two horizontal plates of the superior maxillæ, and between the corresponding plates of the palatal bones.—*The squamosal suture.* This variety is characterized by two bevelled surfaces which are opposed the one to the other. The outer overlaps the inner, and suggests an arrangement similar to that existing between the scales of fishes. An example of the squamosal suture is seen in the human body in the union between the squamous portion of the temporal bone and the parietal bone.—*The dentate suture.* In this form tooth-like processes project from the opposed surfaces.—*The serrate suture.* This resembles the dentate, but is distinguished by the processes being more or less saw-like. The so-called *limbose suture* is a combination of the squamosal and serrate.—The interparietal suture is an instance of the dentate and the interfrontal of the serrate.—The sutures seen on the under surface of the calvarium are all harmonic, no matter what they may be upon the upper surface.

Following upon external force an imperfectly defined motion is permitted between bones united by sutures that have not attained their full degree of development. The most important of these, according to P. Budin,[2] takes place in the fœtal skull at the suture between the ascending portion of the occipital bone and the centres at the sides of the foramen magnum. The motion of the former upon the latter is described by this writer as hinge-like in character. When the ascending portion is bent forward on the suture, it is said to be flexed, and when backward, to be extended. Budin believes that one or the other of these movements, according to the presentation of the head, always takes place during parturition.

[1] For the classification of joints see the table on p. 208.

[2] De la Tête du Fœtus au Point de Vue de l'Obstétrique. Paris, 1876, 72.

SYNCHONDROSIS. Synchondrosis serves to unite the several centres in immature cartilage-bones. In the long bones it joins the epiphyses with the shaft, and the different centres of the irregular and tabular bones with one another. Good examples of synchondrosis are seen between the sphenoid and the occipital bones, at the costo-sternal articulation, in the body of the sternum, and among the different parts of the hyoid bone. The motion of synchondrosis is exceedingly slight.

SYMPHYSIS. The bone-surfaces in symphysis are flat and gently concave, as in the vertebræ, or irregularly sinuate, as in the pubic bones at the interpubic articulation. The surfaces are not free, but are held together by disks of fibro-cartilage, the short, tense fibres of which are so arranged that they are compactly interlaced toward the periphery, but are elastic and succulent toward the centre. In the interpubic articulation a synovial sac may be present. The bones uniting in a symphysis are further strengthened by accessory bands.

Symphysis, as here defined, includes the amphiarthrosis[1] of the older writers. Meyer includes symphysis under arthrodia,[2] intending thereby to bring together all forms of broad and nearly flat movable articular surfaces.

Examples of symphysis are seen between the bodies of the vertebræ (excluding the atlas and the axis), between the sacrum and the coccyx, between the pubic bones, and between the ilium and the sacrum.

Both synchondrosis and symphysis require considerable exercise of force to disturb their equilibrium, and when the force ceases to act the joint surfaces resume the position of rest by reason of their own elasticity. Hence no forms of check or limiting mechanisms are met with in these joints.

[1] Amphiarthrosis also embraced the union between the different carpal and tarsal bones, especially where flat surfaces were connected by interosseous ligaments.

[2] The term "Arthrodia" is already in use to signify a group of articulations having a subordinate position in the one this writer would assign it. If it be held to be important to have a word to include all forms of movable joints, the word Lyenarthrosis is suggested as one that would be appropriate. This word implies that a joint therein placed is *unfixed*, as opposed to any given variety of Sutura and Synchondrosis which is *fixed*.

TABLE OF JOINTS.[1]

SUTURA, includes the union of bones arising from membrane. The bone surfaces are varied.	HARMONIA, when the surfaces are smooth or slightly irregular. SQUAMOSA, when they overlap like the scales of a fish. DENTATA, when the edge of the bone is armed with tooth-like processes. SERRATA, when the processes named in the last group are saw-like.
SYNCHONDROSIS, includes the union with cartilage of bones arising from that tissue. The bone surfaces are flat or irregular.	
SYMPHYSIS, includes the union by means of fixed fibro-cartilage of bones which are without encrusting cartilages. The articular surfaces of the bones are flat or nearly so.	
DIARTHROSIS, includes the union of bones that present to one another convex or concave surfaces of encrusting cartilages, and are covered with synovial membrane.	Diarthrotic joints are called ARTHRODIAL when the curvatures are faintly expressed. They are called SPHERICAL when the curvatures are pronounced and their radii equal. They are called CYLINDRICAL when the curvatures are pronounced and their radii unequal: *Hinge*, with a trochlear or pulley-like surface. *Screw*, with axis oblique to axis of bone. *Saddle*, with opposed surfaces resembling those of a saddle. CONICAL, when the form is that of a cone. COMPOSITE, when the various features of diarthrosis are combined.

[1] The classification used by English writers (see Gray's Anatomy) is herewith presented for purposes of convenience in reference.

- *Synarthrosis* or immovable joint. Surfaces separated by fibrous membrane, without any intervening synovial cavity, and immovably connected with each other. As in joints of cranium and face (except lower jaw).
  - *Sutura*. Articulation by processes and indentations interlocked together.
    - *Sutura vera* (true) articulate by indented borders.
      - *Dentata*, having tooth-like processes. As in interparietal suture.
      - *Serrata*, having serrated edges, like the teeth of a saw. As in interfrontal suture.
      - *Limbosa*, having bevelled margins, and dentated processes. As in fronto-parietal suture.
    - *Sutura notha* (false) articulate by rough surfaces.
      - *Squamosa*, formed by thin bevelled margins, overlapping each other. As in squamo-parietal suture.
      - *Harmonia*, formed by the opposition of contiguous rough surfaces. As in intermaxillary suture.
  - *Schindylesis*. Articulation formed by the reception of a thin plate of one bone into a fissure of another. As in articulation of rostrum of sphenoid with vomer.
  - *Gomphosis*. Articulation formed by the insertion of a conical process into a socket. The teeth.
- *Amphiarthrosis*. Mixed Articulation.
  - 1. Surfaces connected by fibro-cartilage, not separated by synovial membrane, and having limited motion. As in joints between bodies of vertebræ.
  - 2. Surfaces covered by fibro-cartilage; lined by a partial synovial membrane. As in sacro-iliac and pubic symphyses.
- *Diarthrosis*. Movable joint.
  - *Arthrodia*. Gliding joint; articulations by plane surfaces, which glide upon each other. As in sterno- and acromio-clavicular articulations.
  - *Enarthrosis*. Ball-and-socket joint; capable of motion in all directions. Articulations by a globular head received into a cup-like cavity. As in hip and shoulder-joints.
  - *Ginglymus*. Hinge joint; motion limited to two directions, forwards and backwards. Articular surfaces fitted together so as to permit of movement in one plane. As in the elbow, ankle, and knee.
  - *Diarthrosis rotatoria* or *Lateral Ginglymus*. Articulation by a pivot process turning within a ring, or ring around a pivot. As in superior radio-ulnar articulation, and atlo-axoid joint.

The above classification is based upon a mixture of form and function, and is arbitrary. The one proposed in the text is based upon form alone, and is in harmony with the facts of development.

The main divisions of the old classification suggest three varieties of joint—the immovable, the mixed, and the movable. But joints either move or they do not; the language designed to describe an intermediate, mixed joint is of necessity inexact.

The varieties Schindylesis and Gomphosis are ignored in the classification of the text. The former is not a suture, since it occurs beween two bones of cartilaginous origin. It is a coaptation, the result of an obliterated synchondrosis, a condition which does not demand a special name. The term "fissure" is inappropriate for the sphenoidal aspect of the vomer. Of variable form, this surface is often narrowed, but never fissured.—The insertion of the teeth in sockets is in no sense articular. "Gomphosis" should be omitted from a classification of joints.

The term Symphysis is employed in place of "Amphiarthrosis," which, as a term having systematic value, is discarded. The presence of a synovial sac in some forms of symphysis is not sufficient ground on which to base a distinct variety.

Diarthrosis and its divisions are essentially the same as in the classification adopted in the text.

Symphysis permits of a slight motion only between the bones united by its means. When a number of small bones, as the vertebræ, are thus joined, the motion between any two is inconsiderable, but is naturally greater when the joints between all the bones act together. The motions of the vertebral column are by this means shown to be great; for the backbone can be flexed, extended, and bent from side to side. At the pubis the union enables a slight outward stretching to occur in child-birth. The surfaces here may also glide slightly upon one another, especially if the synovial sac is developed.

DIARTHROSIS. In diarthrosis the opposed bony surfaces are concavo-convex. The bones are free; the synovial membrane constant; the capsule loose, and ordinarily strengthened by muscles and accessory ligaments. The joints of the limbs are exclusively of this character. They range from the simplest to the most complicated forms. So great is the motion permitted in diarthrosis, that all the surfaces of a given joint are never in contact with one another at the same time. In each particular position assumed, in passing from complete flexion to complete extension, opposite facets, that are specially adapted to maintain such position, are brought in contact with each other. Such areas of contact change successively as the path of movement (by which term is meant the direction taken by a given articular surface in gliding over another) is followed. In the knee-joint, for example, it is found that in flexion the tibiofemoral facets near the posterior aspect of the joint are in contact, while the anterior surfaces are separated. In like manner, during extension the anterior surfaces are in contact, while the posterior are separated. The parts in contact may be said to be active, and those not in contact to be at rest. In addition to the above it may be seen that one of the bones composing the joint is fixed or inclines to be, while the other moves upon it. The fixed portion furnishes the *axis of rotation.* The plane on which the moving bone swings is the *plane of motion*, and moves in certain relations to the *axis of rotation* according to the special shapes of the joint surfaces. Thus in a rotary joint the plane of motion is called the *plane of rotation*, and in a hinge joint the *plane of flexion* or *extension.*—A pair of corresponding facets which are known to be active in certain positions of the joint may be called after the kinds of activity they are engaged in. Thus one can speak of facets of flexion, or the facets of extension, etc.

When the convexity is proximal, and the concavity distal, as in the astragalo-scaphoidal joint, the idea of the convexity *resting* within or upon the concavity is suggested; whereas, when the concavity is proximal, and the convexity is distal, as in the shoulder-joint, the idea of the convexity falling away, or *swinging* within the concavity, is suggested. The former of these joints expresses a state of rest; the latter one of motion.

The proper method of studying the motions of diarthrodial articulations is as follows:—

(1) The simplest form of an articulation is that in which the distal facet of one bone is in the same axis as the proximal facet of the opposed bone. Such joints may be termed *primary joints*, and the two corresponding facets, *primary facets.* In the knee-joint it is found that the longitudinal axis answers to the outer femoral condyle, and hence the *primary* facet is to be found upon this surface; while the facet formed upon the inner femoral condyle is not primary, but *secondary*, and is a special feature added to the primary character of the joint.—The articular surfaces upon the sides of certain bones, as those between the tarsal and the metatarsal bones, and between the tibia and the fibula, are of significance different from that of either of the preceding; these may be termed the *lateral* or *tertiary* facets.

A joint may be said to be at rest when the least amount of pressure exists between its opposed facets. It has been already noted above that extremes of extension and flexion fix a joint. The position of rest is ordinarily one between these two extremes, namely, the one termed *semi-flexion.*

The supine position tends to rest the joints of the limbs, particularly those of the lower limb, since it removes the pressure of the weight of the body. If, however, the assumption that muscular action controls joint movements be correct, it follows that joints cannot be rested even in the supine position so long as their muscles are acting inordinately or in vicious directions. Hence the question of the rest of muscles enters into every problem of rest, and lies at the basis of all rational treatment of joint diseases. Any apparatus designed to keep the joint at rest must include all the muscles acting upon it.

(2) The presence of a disk of fibro-cartilage between two cartilaginous articular surfaces tends to divide the joint, in a mechanical sense, into two chambers; in the knee there is a chamber between the femur and the disk on the one hand, and the disk and the tibia on the other.

When it is remembered that these disks are,

primarily, outgrowths from the capsule in the motions of which they participate, and into which, as in the external inter-articular disk of the knee-joint, they project, it is seen that these disks are important factors in the movements of the articulations. When the living subject is standing erect, and the weight of the body is thrown chiefly upon the outer femoral condyle, the action of flexion is initiated by the change in position of the external disk, by means of which the tibia is moved slightly inward, and placed in a favorable position for gliding backward or inward along the inner femoral condyle.

Flexion indicates the position of the limb in which the most acute angle possible exists between its segments.[1] *Extension* is the reverse of flexion; it is the position in which the angulation between the segments is the least possible. If extension is carried beyond 180°, dorsal flexion begins. In flexion and extension, viewed as one movement, a form of rotation is seen, the distal end of the movable bone describing a wide arc of a circle about that of the fixed bone.

Rotation is a movement of a bone upon itself in its longitudinal axis, as in the motion of the radius on the ulna. When rotation occurs with the limb describing a circle it is called *circumduction*, and is the direct transmutation of one position of flexion into another, and the rotation of one or both bones in any position which the two bones may effect toward each other.

Adduction is the traction of the part toward the median line. *Abduction* is the traction of the part away from the median line.

When a movable articulation becomes immovable it is said to be *fixed*, and the passage from one to the other condition is controlled by muscular action.

The arthrodial variety of diarthrosis; or the flat joints.—In this, the simplest form of diarthrosis, the surfaces are so slightly concavo-convex that they have been described by some writers as plane.

In the assertion often made that the apposed surfaces of some bones are almost flat, we have no proper distinction drawn between the infinitely large varieties which can be created by slightly modifying nearly flat surfaces. It would be more accurate to say that such bones are opposed to one another by slightly concave and slightly convex surfaces, and that the motions between such surfaces do not glide so much as they rotate one upon the other, and are thus seen not to differ in kind from any other form of diarthrosis. In a joint of this kind the movement is necessarily slight. Examples of arthrodial joints are seen between the oblique processes of the vertebræ,[1] and the joints between some of the bones of the carpus and the tarsus.

[1] For examination of tumors in position of flexion see Gross's System of Surgery, 5th ed. 1872, ii. 1065.

The spherical variety of diarthrosis (ball-and-socket joint, or Enarthrodia). The convexity is marked in this form, and the concavity is smaller than it. Such a joint possesses many axes of rotation. It is with such that circumduction occurs. The hip and shoulder are examples of the spherical joint. It maintains on all sides an equal degree of motion.[2]

The cylindrical variety of diarthrosis.—The convexity in this division is broad and elliptical, and suggests the form of the condyle.

The cylindrical joints are divided into the (*a*) hinge joint or ginglymus; (*b*) the screw joint; and (*c*) the saddle joint.

(*a*) *The Hinge Joint* (ginglymus).—This is the best expression of a cylindroid joint. The axis of rotation is perpendicular to the axis of the moving bone, or, as in the case of the elbow, the axes of two bones, the radius and ulna, since both of these describe curvations round the axis of rotation.

The paths of movement of the hinge joint are free within certain limits. These degrees of freedom are of necessity fixed by the direction of the greatest convexity. The co-operation of the surfaces is exact.

(*b*) *The Screw Joint* (spiral joint).—In some facets of the more complex cylindrical joints the axis of the oblong convex surface falls obliquely to the axis of the concavity in which it plays. Such, for example, is the oblique facet on the inner condyle of the femur.

(*c*) *The Saddle Joint.*—This is so called from the resemblance its surfaces bear to those of a saddle. Each articular surface is convex in one direction, and concave in the opposite. The saddle joint is peculiar in presenting its apposed concave portion in such fashion as to tend to embrace the convexity of the proximal one. The saddle joint can be flexed, extended, abducted, and adducted, and, as a result of these varied movements, circumducted. It effects on the plan of the hinge joint the movements of a ball-

[1] Except the atlanto-axoid articulation, *q. v.*

[2] The terms of the above definition are doubtless not mathematically accurate. The term "spheroidal" is more exact than spherical. Of the two, the last-named is nevertheless preferred, since it is an equivalent of the term "ball-and-socket" in general use.

and-socket joint. The metacarpo-trapezoidal joint is the best example of a saddle joint in the body.

THE CONICAL VARIETY OF DIARTHROSIS (pivot joint).—The convexity in this variety is in the form of a cone or disk, and clasped by a constricting ligament. Since in rotation the bone rolls upon its longitudinal axis, it is found that the axis of rotation of a conical joint agrees with that of the bone on whose periphery it occurs. Examples are seen in the superior radio-ulnar articulation, and in the atlanto-axoid articulation in part.

THE COMPOSITE VARIETY OF DIARTHROSIS.—When the contrasts between the various facets of a joint are inconspicuous, it is said to be simple; when they are decided, it is said to be composite, since it combines in one the features of the spherical, the conical, or the cylindrical joint. A distinct motion is presumed to correlate with each well-defined facet or curvature.

When several kinds of curvature unite to produce a single motion, as, for example, when the rotary motion of the radius against the humerus unites with the hinge-motion of the ulna and humerus, or, as in the wrist, when the three convexities of the bones of the carpus correspond to the concavities of the surfaces yielded by the radius and the triangular ligament, the joint can be said to be *aggregated* (Meyer).

GENERAL REMARKS ON THE DEVELOPMENT OF THE JOINTS.—The differences between the methods of articulation already described are based upon the manner after which the bones are developed.

It will be remembered that the bones of the sides and vertex of the brain-case, and some of the bones of the face, develop from fibrous tissue (p. 97); such bones are connected by intervals of unossified membrane of varying width, and in time they unite by sutures which are so adapted as to permit of the increase in size of the brain, and the proper formation of the chambers of the face, without impairing the strength of the skull. When the growth of these structures is complete, the sutures, as a rule, disappear. This variety of union is called by the older writers *Syndesmosis*, the bones being joined by fibrous tissue, which in this sense is functionally the same as ligament, except that the tissue is continuous with the bed or plane of each bone, instead of being adjusted on the sides.

In the event of a joint arising between two of a series of cartilage bones, there exists, as in the above variety, an unossified interval which is continuous with the opposed ends of the bones. But this intervening tissue, instead of remaining undifferentiated, is developed either into cartilage or fibro-cartilage. Should the development be arrested at this stage, and the mediating tissue be cartilage, the variety of union known as *Synchondrosis* occurs, an example of which is seen between the sphenoid and the occipital bones.

If the mediating tissue be fibro-cartilage, *Symphysis* occurs, as is seen in the intervertebral and interpubic joints.

Should the ends of the bones develop layers of cartilage, and the intervening fibro-cartilage be parted therefrom by synovial membrane, and its own synovial surfaces be separated from one another, the form of joint arises such as is seen in the claviculo-sternal, the temporo-maxillary, and the carpo-ulnar joints.

If the fibro-cartilage is rudimentary, and attached only to the capsular ligament, and the synovia-bearing surfaces are continuous with one another, the form of joint seen at the knee is recognized.

If after the ends of the bones are furnished with cartilage, the fibro-cartilage is absorbed save a small band in the centre, the form of joint seen in the costo-vertebral and the ilio-femoral articulations arises. At least one of the crucial ligaments of the knee may be looked upon as the persistent central portion of the same primordial fibro-cartilaginous tissue which also remains on the sides of the joints in the former as interarticular disks.

If the mediating cartilage and fibro-cartilage entirely disappear, the form of movable joint exemplified in the elbow or the shoulder is seen.

The degree of possible influence exerted by muscle in effecting the evolution of the various forms of joints has as yet not been determined. It may be more than a coincidence that arrest of development at the stage of symphysis is seen in localities where comparatively slight motion occurs, as in the vertebral column and pubis; while localities in which the true synovia-secreting joints are seen are moved freely by highly specialized and powerful muscles. Bernays[1] does not credit muscle with any primal influence, since he found in the knee-joint that the synovial membrane developed, and the essentials of the joint surfaces appeared before the joint became movable. It is at a later period only in his judgment that the influence of irregular muscular action is at all felt. J. Cunningham,[2] however, in endeavor-

[1] Morph. Jahrbuch, 1878, Heft 3, p. 403.

[2] Journ. Anat. and Phys., 1878, p. 88

ing to explain how an adventitious synchondrosis has eventually become developed into a diarthrodic joint, assumes that it has been accomplished by the traction of muscles. He found that among examples of detached epiphyseal centres of the vertebræ some were attached to the main bone by synchondrosis, and some by diarthrodia, and that the latter variety existed where there was the greatest indirect motion due to muscular action.[1]

C. H. Hueter[2] has written several suggestive papers on the peculiarities of the articular surfaces of the bones in the child and the adolescent. These papers have important bearings upon the subject of congenital deformity, and indirectly upon the etiology of all obscure lesions of joint surfaces of limbs. By reason of the difficulty presented in an attempt to epitomize Hueter's elaborate statements, the reader is referred to the original.

List of authorities consulted in preparing the above section.

An Introduction to Human Anatomy, etc., Wm. Turner, Prof. of Anat. in Univ. of Edinburgh, Edinburgh, 1867.—See also article "Anatomy," Encycl. Brit. 9th ed.

Lehrbuch der Anatomie des Menschen, G. Hermann Meyer, Leipzig, 1873.

Article "Articulations," Prof. Todd, Encycl. Anat. and Phys., Vol. I.

Der Bau des Menschlichen Körpers, etc., Prof. Chas. Aeby, Leipzig, 1871.

THE JOINTS AND LIGAMENTS OF THE TRUNK.

The Joints and Ligaments of the Trunk are arranged as follows:—

Those of the Vertebral Column.
Those of the Lower Jaw.
Those of the Thorax.

The Joints and Ligaments of the Vertebral Column.

The Ligaments of the Vertebral Column are arranged for convenience into—

(1) The General Vertebral Ligaments.

(2) The Special Ligaments of the Atlas, the Axis, and the Occiput.

(1) The General Vertebral Ligaments. These are eight in number, as follows:—

The Intervertebral Disks.
The Anterior Vertebral Ligament.
The Posterior Vertebral Ligament.
The Interspinous Ligament.
The Supraspinous Ligament.
The Intertransverse Ligament.
The Ligamenta Subflava.
The Ligamentum Nuchæ.

The Intervertebral Disks or Cartilages (fig. 1, Plate XXXVI., fig. 2, Plate XXXVII.) connect the bodies of the vertebræ together from the axis downward. The general form of each disk answers to the shape of the bodies of the vertebræ between which it is placed. In addition to uniting the vertebræ, the disks aid in defining the intervertebral foramina, and, in the dorsal vertebræ, the facets which articulate with the ribs. The disks are narrowest between the third to the seventh dorsal vertebræ and between the bones of the coccyx. Each disk is composed of a laminated exterior and a pulpy interior. The former portion makes up a little more than one-half of the entire disk. The pulpy portion is susceptible of great change in form. Thus, when the bodies of a pair of adjoined vertebræ are divided transversely through the middle, it arises above the plane of the section.

The peripheral fibres are composed of concentric layers of fibrous tissue and fibro-cartilage. These layers are arranged nearly vertically laterally, but are slightly curved as they approach the median line. Each layer is composed in such a way of oblique alternating fibres that successive arrangements of crossing fibres are seen. The pulp is placed a little nearer to the posterior than to the anterior border. Sometimes, according to Luschka, it sends a bud-like prolongation backward to the vertebral canal. Composed as it is of a loose stroma of fibrous tissue, holding in its meshes cartilage cells of various sizes, the pulp is thought to represent in the adult skeleton survivals of the chorda dorsalis, and to serve the purpose—under the great pressure to which it is subjected—of a ball or pivot held by stout peripheral fibres within the apposed axial surfaces of the bodies of the vertebræ.

In the cervical and the lumbar region the disks are thicker in front than behind. In the cervical region they about equal the thickness of the body of the vertebræ. In the dorsal region the disks are a little thicker behind than in front. The disk is the same height both before and behind at the junction

[1] For an elaborate and experimental paper upon the capacities of the joints, the modifications of shapes, and position of the same as dependent upon distension, see Ed. Albert, in Stricker's Med. Jahrbücher, 1873, p. 304.

[2] Virchow's Archiv, 1863.

of the cervical and the dorsal and the dorsal and lumbar vertebræ. It is estimated that the length of the intervertebral disks equals about one-fourth of the entire length of the spine.

Relations.—The disks in front are in relation with the anterior vertebral ligament, and by many muscles, such as the Rectus Capitis Anticus Major, the Longus Colli, the Diaphragm, and the Psoas Magnus, and behind with the posterior ligament, with which they more intimately unite than with the anterior. Upon the sides in the neck they are in connection with the Intertransversalis muscles; in the dorsal region with the heads of the ribs; in the lumbar region with the vessels and nerves which traverse the intervertebral foramina.

Remarks.—According to W. Adams,[1] ulceration of the intervertebral cartilages is a not unfrequent lesion in Pott's disease, and may exist independently of vertebral necrosis. From the examination of several cases of spinal disease in the early stages, and from the study of specimens in the London Museum, Mr. Adams concludes that in the majority of instances of destructive disease of the spine, the affection commences in ulceration of one or more of the intervertebral fibro-cartilages, and generally in the central portions of the disk. The disease from first to last is sometimes limited to the intervertebral substance.

The Anterior Vertebral Ligament (figs. 1 and 4, Plate XXXVI., fig. 1, Plate XXXVII.) extends along the front of the vertebral column from the axis to the second sacral vertebra. Straight above, it increases in breadth as it descends to a point opposite the dorsal vertebræ, where it forms, in addition to the central fasciculus, two lateral portions, which, however, are thin and present numerous openings for the passage of vessels. The ligament adheres anteriorly to the bones at such places, and throughout is firmly attached to the intervertebral disks. In minute structure the ligament displays three distinct layers of fibres. The deepest are the shortest, and pass across each disk to the adjacent bodies of the vertebræ. The next pass from one bone to the third beyond, while the most superficial arise from one bone to be inserted in the third or fourth beyond.

In the neck the anterior vertebral ligament appears as a shining line between the Longus Colli muscles. In front lie the pharynx and œsophagus. Within the thorax, the azygos vein, the thoracic duct, the descending aorta, and the vena cava lie upon the ligament. Opposite the lumbar vertebræ the crura of the Diaphragm and the Psoas muscle are attached to it.

The Posterior Vertebral Ligament (fig. 1, Plate XXXVII.), thinner than the anterior, extends along the posterior surface of the bodies of the vertebræ, from the basilar process of the occipital bone to the lower lumbar vertebræ or even to the coccyx. It is broader above than below. Within the region of the neck it is spread evenly over the bodies of the vertebral disks, and is thus of exceptional strength; but through the rest of its position it expands over the disks, but contracts upon the borders of the vertebræ opposite the pedicles, so that viewed as a whole it presents a festooned appearance. Above it is adherent to the dura mater. Elsewhere it is distinct, and permits the vertebral veins to lie between it and the bone. Sappey states that it possesses more elastic tissue than does the anterior ligament. The minute arrangement of the fibres is essentially the same as in the anterior vertebral ligament.

Remarks.—Both the anterior and the posterior vertebral ligaments are of great strength, and aid in limiting the motions of the vertebral column. Thus the anterior ligament acts as a check to extreme backward motion, as the posterior ligament prevents extreme forward motion. It is probable that after displacement of an intervertebral disk the ligaments in question may prove to be capable of modifying the degree of dislocation of the contiguous vertebral bodies. Especially is this likely to be the case where the ligaments are of unusual strength.

The Interspinous Ligaments (fig. 2, Plate XXXVII.) are thin membranous bands which unite the spines, from the root to near the apices, of all the vertebræ from the seventh cervical to the sacrum. They are the least developed in the dorsal region, but are thick and quadrangular in the lumbar.

The Supraspinous Ligament extends between the summits of the spines of the vertebræ posteriorly to the interspinous ligaments with which it is continuous. In the neck it is thought to be represented by the ligamentum nuchæ. The ligament is best developed in the lumbar region, where it assists in closing the spinal canal. It is connected by numerous points of contact with the Erector Spinæ muscle. According to Quain, its posterior fibres pass downward from a given vertebra to a distance answering to the third or fourth vertebra below; those more deeply situated reach only from one to the next or the second below.

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[1] Tr. Path. Soc. Lond., v. 1854, 243.

The Intertransverse Ligaments are bands extending between the transverse and the oblique processes of the vertebræ. They are best seen in the lower dorsal and the lumbar vertebræ. They are rudimentary in the rest of the dorsal vertebræ, and rudimentary or absent in the cervical region where their places are taken by the Intertransverse muscles.

The Ligamenta Subflava (fig. 2, Plate XXXVII.) are composed entirely of compact elastic tissue. They lie between the laminæ and, in part, the oblique processes of the vertebræ from the axis to the sacrum, in such manner as to be seen to the best advantage from in front. Each ligament is attached a little in advance of the lower edge of the lamina above and to the posterior surface of the lamina below. It follows that the fibres composing it are not vertical, but are inclined a little downward and backward, and that the height of the ligament is slightly in excess of the space between the pair of laminæ it unites. The ligaments slightly diminish in size from above downward, but are thicker in the loins than elsewhere. Each ligament is stoutest near the base of the lamina, but slightly increases in breadth toward the spine, where it forms a continuous band, pierced by several minute nerves. The fibres are more or less continuous with those of the interspinous ligaments. Between each ligament and the dura mater are interspersed a little cellular tissue and a few veins.

The ligamenta subflava assist the erector muscles of the spine in maintaining the erect position of the spine, and in recovering this position from one of forced flexion.

The Ligamentum Nuchæ extends upwards from the spines of the cervical vertebræ, and is attached above to the occipital bone. It is composed of two parts: the superficial part extends from the spine of the seventh cervical vertebra to the occipital protuberance; and the deeper part is formed by the union of the successive bands which arise from the remaining cervical spines, including the posterior tubercle of the atlas, and is attached to the occipital crest.—The ligamentum nuchæ serves as an intermuscular septum between the right and the left sets of muscles of the back of the neck, and aids in a minor degree in supporting the head. It is the rudiment of the more pronounced elastic ligament of quadrupeds. Its upper portion may be felt in the living subject when the head is forcibly flexed upon the neck. According to Luschka, the ligamentum nuchæ restricts abscesses of the back of the neck to their own side of the median line.

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(2) The Special Ligaments of the Atlas, the Axis, and the Occiput are nine in number, as follows:—

- The Transverse Ligament.
- The Posterior Atlanto-Axoid Ligament.
- The Capsular Ligaments.
- The Synovial Sacs.
- The Anterior Atlanto-Axoid Ligament.
- The Posterior Occipito-Atlantal Ligament.
- The Occipito-Axoid Ligament.
- The Anterior Occipito-Atlantal Ligament.
- The Odontoid or Check Ligament.

The Transverse Ligament (figs. 2 and 3, Plate XXXVI.) extends across the central space inclosed by the atlas, and is attached by its extremities to the inclined roughened surface on the inner side of each lateral mass. It divides the space into two parts: an anterior third for the reception of the odontoid process of the axis; and a posterior third for the spinal cord and membranes. The ligament is thick, and slightly concave forward and convex backward, and from this circumstance has been termed by some authors the *semilunar* or *semicircular ligament.* It has been described by others as pitcher-shaped, the lip flange being in contact with the head of the odontoid process, while the lower vertical part embraces the

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EXPLANATION OF PLATE XXXVI.

Fig. 1. Articulation of the bodies of the vertebræ.

Fig. 2. Section of the occipital bone, the atlas and the axis seen from behind, showing the articulation of the head with the atlas and the axis.

Fig. 3. The atlas, showing the contents of the vertebral canal and joint between the odontoid process of the axis and the atlas.

Fig. 4. A portion of the bodies of the vertebræ, with the vertebral ends of the ribs in position, showing the anterior vertebral and the costo-vertebral ligaments.

Fig. 5. A dorsal vertebra and portion of adjacent ribs, showing the costo-sternal ligaments.

PLATE XXXVI

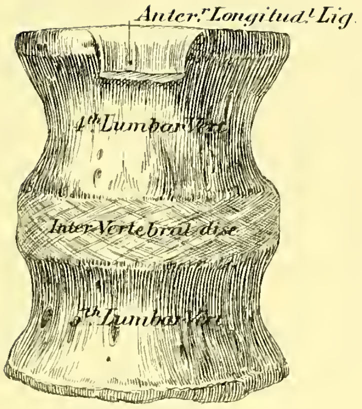


Fig 1

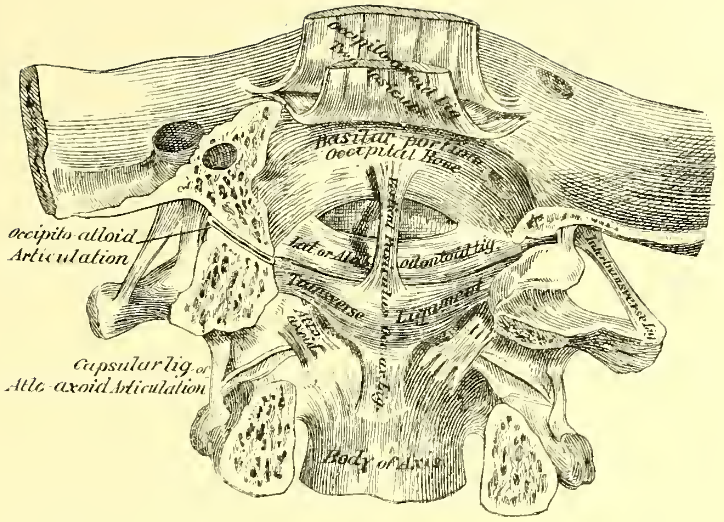


Fig 2

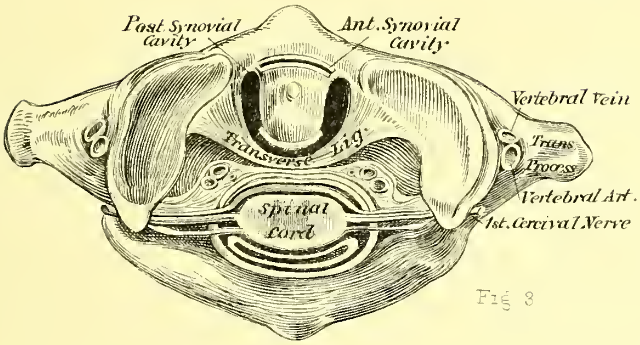


Fig 3

Fig 4

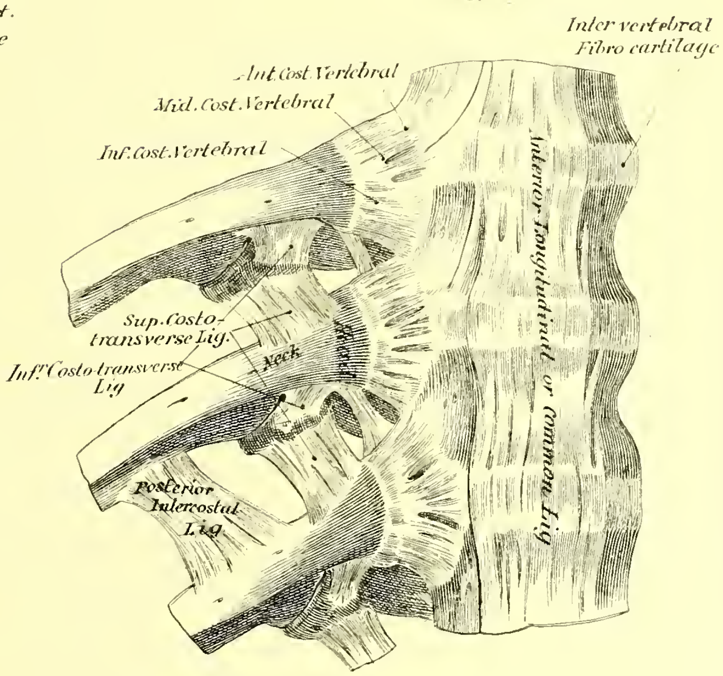
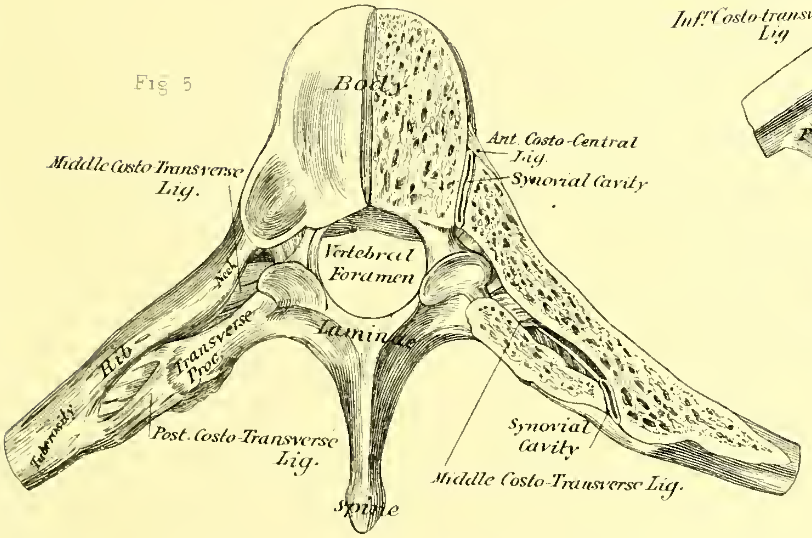


Fig 5



C. Sinclair & Son, Lith.

neck of the process. The posterior surface of the odontoid process is covered with cartilage for action with the anterior surface of the ligament. Extending from the upper part of the ligament to the occipital bone is a small vertical bundle of fibres, and downward from the ligament to the body of the axis a second bundle. These make, together with the transverse ligament, a cross-like structure, which has received the name of the *crucial ligament.*

REMARKS.—According to Sappey, the odontoid process is held lightly within the grasp of the transverse ligament, so that if the other structures uniting the atlas and the axis are removed, the process can be inserted and withdrawn with ease.

Luschka regards the transverse ligament as representing in part the unossified vertebra of the atlas. Should this view be accepted, the vertical ligaments above described may be considered as continuations of the posterior vertebral ligament.

The Posterior Atlanto-Axoid Ligament (fig. 2, Plate XXXVI.) extends from the inferior border of the posterior arch of the atlas to the superior border and spine of the axis. The superficial portion is fibrous, and corresponds to the interspinous ligament of the lower vertebræ. The deeper portions contain elastic tissue, and are thought to be rudiments of the ligamenta subflava.

The Capsular Ligaments (fig. 1, Plate XXXVII.) occupy the interval between the occiput and the atlas, and between the atlas and the axis. They are simple environments of the articular surfaces with fibrous membrane, and do not differ from analogous joints elsewhere. They are least developed on the side toward the vertebral canal. The anterior occipito-atlantal articulation is strengthened by the lateral fibres of the posterior occipito-atlantal ligament.

The Synovial Sacs. One of these exists between the odontoid process and the atlas, and another between the posterior surface of the same process and the transverse ligament.

The Anterior Atlanto-Axoid Ligament is a thin membranous structure extending between the lower border of the anterior arch of the atlas and the upper border of the body of the axis.

The Posterior Occipito-Atlantal Ligament extends from the posterior and the lateral margins of the foramen magnum to the upper border of the posterior arch of the atlas, where midway between the occipital crest and the occipital condyle a tubercle of attachment is seen. Its deeper parts are continuous with the dura mater. The ligament extends between the posterior and the lateral margins of the foramen magnum and the upper border of the posterior arch of the atlas. Its lateral portions are attached above to the tubercle which is seen about midway between the occipital crest and the occipital condyle, and below to the posterior edge of the superior articular surface of the atlas. Toward the middle line the ligament closes in the vertebral canal. This portion is made tense when the head is flexed.

The Occipito-Axoid Ligament (fig. 2, Plate XXXVI.) is a broad membranous structure extending between the anterior margin of the foramen magnum and the body of the axis. It is in close connection with the dura mater above, and is continuous with the posterior vertebral ligament below. Between it and the crucial ligament lies a small plexus of veins. A few of the fibres of the occipito-axoid ligament may serve to strengthen the transverse ligament of the atlas.

The Anterior Occipito-Atlantal Ligament consists of a firm, strong membrane, extending from the anterior margin of the foramen magnum to the upper margin of the anterior arch of the atlas. It is strengthened in the middle by a distinct rounded band, which is attached to the anterior tubercle of the atlas. This is described by some writers as the *anterior cervical ligament*, and is supposed by them to be the beginning of the anterior vertebral ligament. The ligament is pierced by the vertebral artery.

The Odontoid (Check, Lateral, Alar) Ligaments (fig. 2, Plate XXXVI.) are short, stout, oblique bands, which arise from the tubercle to the inner side of the occipital condyles. They pass downward and inward, and are inserted into the sides of the odontoid process. Occasionally the fibres intercross in front of the head of the process. Attached to the tip of the odontoid process is an unimportant band of fibres, which unites the axis to the anterior margin of the foramen magnum. It is designed chiefly to cover the space between the top of the atlas and the occipital bone. The closely united interlacing fibres constitute the transverse occipital ligament of Lauth.

THE TEMPORO-MAXILLARY JOINT.

The temporo-maxillary articulation (figs. 1, 2, 3, Plate XXXVII.) is composed of the upper surface of

the condyloid process of the lower jaw, and that portion of the glenoid fossa in advance of the glenoid fissure, together with the articular eminence.

The condyle is held in position by a capsular ligament which is weak in front and at the inner side, but stout behind and to the outer side. A portion of the oblique outer fibres extending from the root of the zygoma to the neck of the jaw has received the name of the *external lateral ligament.*

Upon the inner side of the joint, but not related to it, is a loose, fascia-like band, extending from the spinous process of the sphenoid bone to the inner margin of the posterior dental foramen. This is called the *internal lateral ligament.* Between it and the lower jaw lie the internal maxillary artery and inferior dental nerve.

Within the joint are—

The Interarticular Disk.
The Synovial Sacs.

The Interarticular Disk is of an elliptical form, more broad than long. It is depressed toward the centre below, for the reception of the head of the lower jaw. Above it is depressed in front for the articular eminence, and is elevated behind for the glenoid fossa.

A Synovial Sac is situated one above and one below the disk. The former is the larger and looser of the two. Both sacs may communicate through an opening not unfrequently present in the centre of the disk. The *motions* of the temporo-maxillary articulation are a to-and-fro hinge-like motion, as seen in opening and shutting the mouth; and a lateral motion. In moderate antero-posterior movements the head lies within the glenoid fossa, but in pronounced depression of the lower jaw it glides forward upon the articular eminence.

The Joints and Ligaments of the Thorax.

Under the head of the joints and ligaments of the thorax are embraced—

The Costo-Vertebral Joints and Ligaments.
The Costo-Transverse Ligaments.
The Intercostal Joints and Ligaments.
The Costo-Sternal Joints and Ligaments.
The Sternal Ligaments.

The costo-vertebral joints and ligaments are of two kinds: those placed between the heads of the ribs and the bodies of the Vertebræ—the Costo-Vertebrals proper; and those placed between the angles of the ribs and the transverse processes of the Vertebræ—the Costo-Transverse.

The proper Costo-Vertebrals comprise—

The Anterior Costo-Vertebral.
The Capsular.
The Interarticular.
The Synovial Membrane.

The Anterior Costo-Vertebral (stellate ligament) (figs. 4, 5, Plate XXXVI.) protects the head of the rib from in front. It is attached to the head of the rib, and passes in a radiate manner therefrom to the bodies of the adjacent vertebræ and the intervertebral disk.

The *superior fascicle* (proper anterior costal) is attached to the body of the vertebra above; the *middle* fascicle (middle costo-vertebral) to the intervertebral fibro-cartilage; and the *inferior fascicle* (inferior costo-vertebral) to the vertebra below.

The Capsular Ligament (fig. 5, Plate XXXVI.) is a delicate sac, inclosing the joint which unites the head of the rib and the vertebræ; it is attached to the anterior ligament, where it is stouter than elsewhere.

The Interarticular Ligament, absent in the first, eleventh, and twelfth ribs, extends from the ridge between the facets of the head of the rib to the intervertebral disk. While embraced within the capsule, the interarticular ligament is, properly speaking, not *within* the joint, since a Synovial Sac lies above it and another below it.

The costo-transverse ligaments embrace—

The Superior Costo-Transverse.
The Middle Costo-Transverse.
The Posterior Costo-Transverse.
The Capsular.
The Synovial Membrane.

EXPLANATION OF PLATE XXXVII.

Fig. 1. The basilar portion of the occipital bone—together with the atlas and the axis—showing the anterior vertebral ligament and two capsules opened.

Fig. 2. A sagittal section of the vertebral column and pelvis, showing the various intervertebral and pelvic ligaments.

Fig. 3. The sternum, the costal cartilages, and the sternal ends of the clavicles, showing the articular and ligamentous attachments.

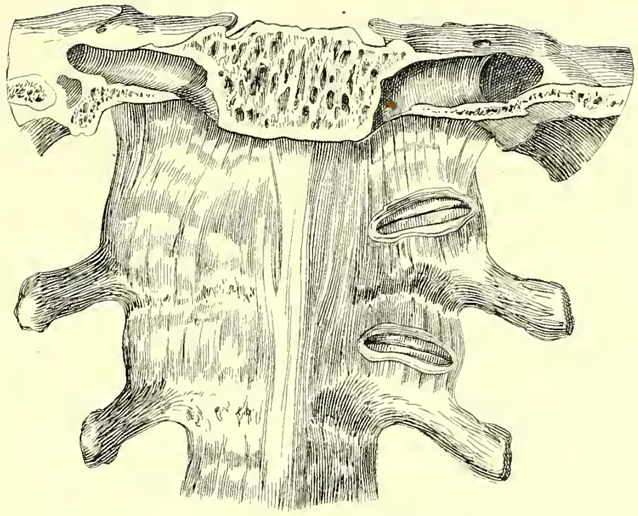


Fig 1

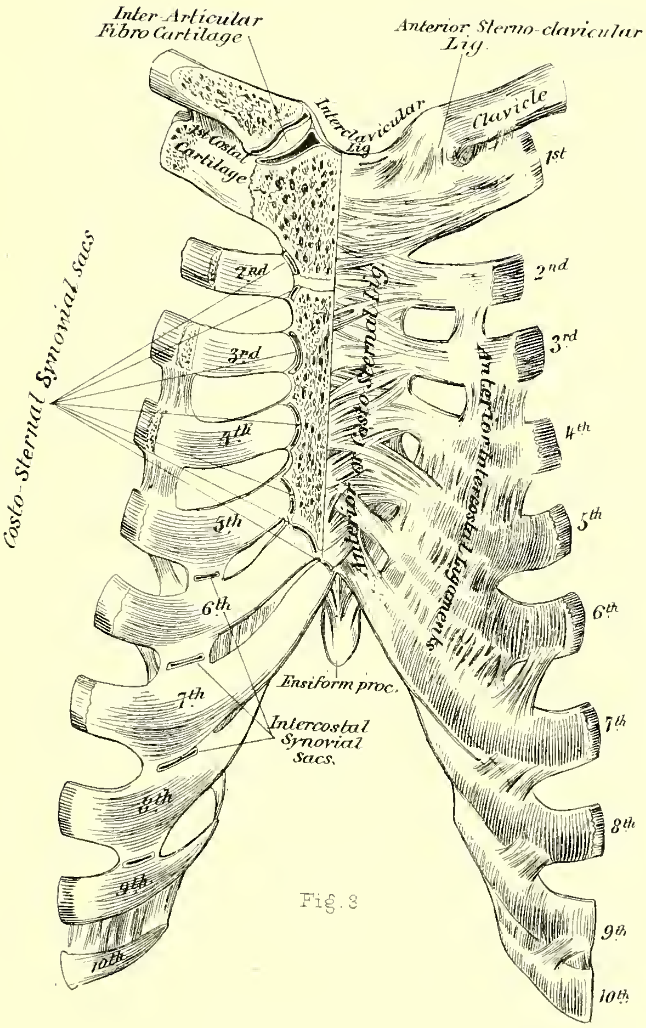


Fig. 3

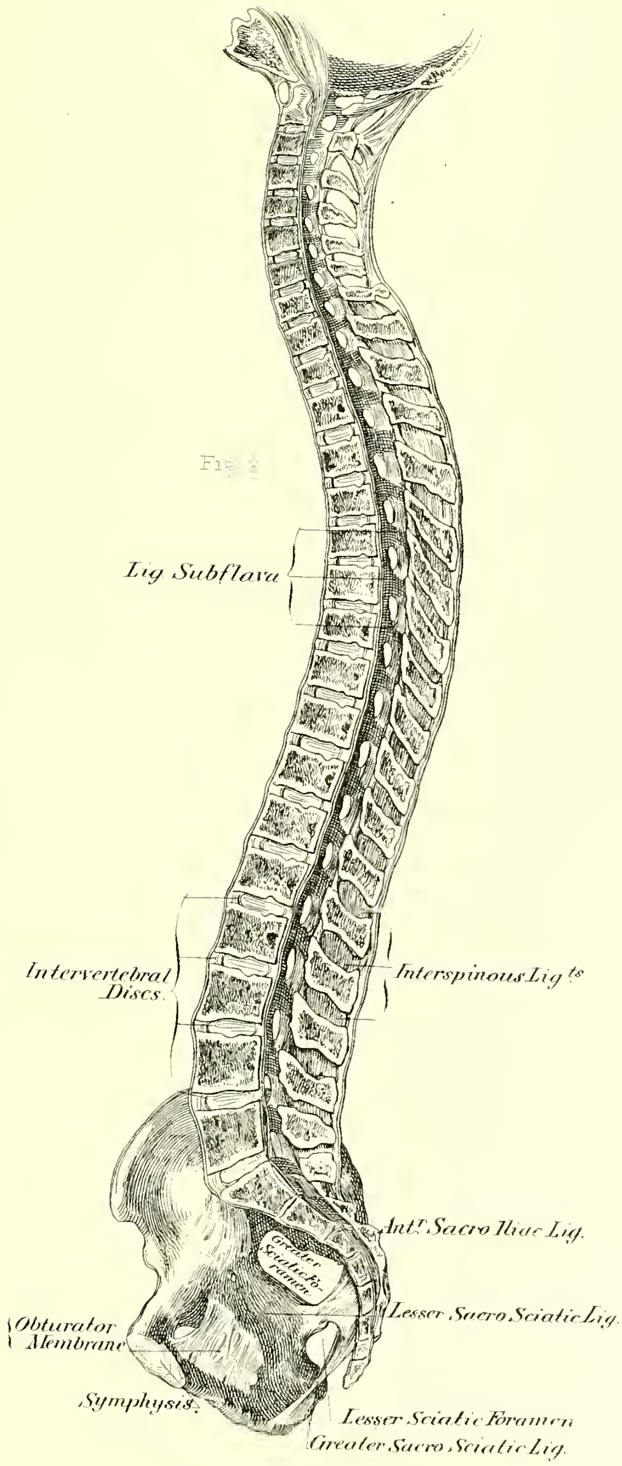


Fig 2

T. Sinclair & Son, Lith.

The Superior Costo-Transverse (anterior) (figs. 4, 5, Plate XXXVI.) is attached below to the upper border of the neck of the rib, and passes upward and outward to be attached to the under surface of the transverse process next above. It is broader than the inferior, and is absent in the first and the twelfth ribs.

The Inferior Costo-Transverse (middle interosseous) (figs. 4, 5, Plate XXXVI.) is attached to the lower border of the neck of the rib, and passes downward and slightly outward by short, stout fibres, to be attached to the anterior surface of the adjacent transverse process. It is rudimentary in the eleventh and twelfth ribs.

The Posterior Costo-Transverse passes from the tip of the transverse process to the tuberosity behind the facet of the rib in connection with it. This ligament is wanting in the eleventh and twelfth ribs.

The Capsular Ligaments unite the articular facets at the tuberosities of the first to the tenth ribs with the facets on the corresponding transverse processes.

Synovial Sacs. Each joint, as above defined, is lined by a simple, delicate synovial membrane (fig. 5, Plate XXXVI).

The intercostal joints and ligaments are as follows:—

The Posterior Intercostals.
The Anterior Intercostals.
The Synovial Membranes.

The Posterior Intercostal Ligaments (fig. 4, Plate XXXVI.) are thin bands, passing between the ribs a short distance in advance of the tuberosities. The Anterior Intercostal ligaments connect the costal cartilages from the sixth to the eighth. The Synovial membranes (fig. 3, Plate XXXVII.) are confined to the region last named. They are inconstant, simple in character, and variable in form. Sometimes the cartilages at points answering to the synovial sacs are furnished with small facets.

The costo-sternal joints and ligaments present the following structures:—

The Anterior Costo-Sternal.
The Posterior Costo-Sternal.
The Capsular.
The Synovial Membrane.

The Anterior Costo-Sternal Ligament is a broad, membranous expansion, passing from the sternal ends of the costal cartilages of both sides, from the first to the seventh, to the anterior surface of the sternum, where the fibres freely interlace. The ligament does not support the costo-sternal articulations, but protects the sternum from in front.

The Posterior Costo-Sternal Ligament is weaker than the anterior, and preserves to the posterior surface of the sternum the relations borne by the anterior costo-sternal ligament to the anterior surface. Special bands pass from the sixth and seventh costal cartilages to the ensiform cartilages.

The Capsular Ligaments, usually described as enclosing the synovial membranes placed between the sternal ends of the costal cartilages and the sternum, are, properly speaking, portions of the anterior and posterior costo-sternal ligaments. Both the synovial membrane and the capsule are absent, as a rule, in the first costal cartilage.

The Synovial Membranes at the second costo-sternal junction are two in number—one above, and the other beneath the ligamentous structure extending from a central ridge on the sternal end of the cartilage to the line of junction between the manubrium and the gladiolus. The remaining synovial cartilages intervene between the ends of the third to the seventh costal cartilages and the sides of the manubrium.

Under the head of the sternal ligaments systematic writers describe special bands of the anterior and the posterior costo-sternal ligaments that unite the manubrium and the gladiolus before the ossification of the sternum is complete. They do not require separate descriptions.

THE LIGAMENTS OF THE SUPERIOR EXTREMITY.

The Ligaments of the Superior Extremity are arranged in the following groups:—

The Claviculo-Sternal Joint and Ligaments.
The Joint and Ligaments of the Shoulder.
The Elbow-Joint and Ligaments.
The Ligaments of the Radius and Ulna.
The Wrist-Joint and Ligaments.
The Ligaments of the Hand.

The Claviculo-Sternal Joints and Ligaments.

The Claviculo-Sternal Joint is composed of the thoracic articular surfaces of the clavicle, the clavicular notch of the sternum, and the upper surface of the first rib. The ligaments holding the surfaces together are—

The Anterior Sterno-Clavicular.
The Posterior Sterno-Clavicular.
The Interarticular Fibro Cartilage.
The Synovial Membranes.

The accessory ligaments are—

The Interclavicular.

The Costo-Clavicular.

The Anterior Sterno-Clavicular Ligament is attached to the front and the upper part of the thoracic end of the clavicle, and passes obliquely downward and inward to the manubrium, and to a slight degree to the cartilage of the first rib. It increases in strength toward the interclavicular ligament with which it is continuous. Its upper fibres are in part contiguous to the clavicular fibres of the Sterno-Cleido-Mastoideus.

The Posterior Sterno-Clavicular Ligament is attached to the posterior and the lower portion of the thoracic end of the clavicle, and passes in a somewhat radiating manner to the sternum and the cartilage of the first rib.

The articular surfaces embraced by the above ligaments yield unusual features. Instead of presenting concavo-convex facets, they are so shaped that the transverse (frontal) diameter of the clavicle is adapted to the antero-posterior (sagittal) diameter of the sternum; both surfaces are more or less saddle-shaped, and the clavicular surface is the larger.[1] In order to make the surfaces in a degree coadaptive, the *Interarticular Fibro-cartilage* is interposed. This disk is of a subrounded shape, wider and thicker above than below, while thin in the centre. It is held more intimately to the clavicle than to the thorax, and is placed obliquely from the upper border of the bone, downward and outward to the cartilage of the first rib. Its anterior surface is convex from within outward, and slightly concave from before backward. It answers only to the upper two-thirds of the clavicular surface;—the lower triangular facet which rests on the first rib is ordinarily not in contact with it. The disk exhibits many varieties. It becomes thinned with old age, and may be perforated, or even absent.

The space between the disk and the sternum, and the space between it and the clavicle, are distinct; each is lined with a synovial membrane. The lateral cavity is much the more extensive of the two, is prolonged a short distance beneath the clavicle, and, as a rule, admits from beneath a synovial fold that corresponds in position with the costal surface of the bone. This portion of the joint may, indeed, be entirely separate from the rest.

The Interclavicular Ligament is a strong, coarsely-textured prismatic or flattened band extending across the supra-sternal notch between the sternal ends of the clavicles. At its ends the ligament is strengthened by slips which pass to the upper portion of the interarticular disk, and to the margin of the manubrium.

The Costo-Clavicular Ligament (rhomboid ligament) extends obliquely upward and backward from the upper margin of the first rib to the rough impression on the under surface of the clavicle near its thoracic end. It is strong, flat, and composed of oblique fibres. The ligament is covered by the Pectoralis Major muscle, and is stronger in the female than the male. The thin lateral edge is in relation with the median border of the Scalenus Anticus muscle.—It is subject to great variation. In rare instances Luschka has seen a process of bone take its place.

Fracture of the clavicle to the median side of the costo-clavicular ligament does not[1] prevent the outer fragment from passing forward.

Movements.—The movements of the sterno-clavicular articulation are of two kinds—one which partakes of the ill-defined but wide range seen in symphysis, and another more limited, which is seen in diarthrosis. The former exists between the axial surface of the clavicle and the sternum. The latter

[1] The clavicular surface is concave above and in the centre, but convex below, while the sternal is elongate transversely, concave from within outward, and a little convex from before backward.

[1] R. W. Smith, Dublin Journ. Med. Sci. 1870, 8.

EXPLANATION OF PLATE XXXVIII.

Fig. 1. Sagittal section of the temporal and inferior maxillary bones, showing a similar section of the temporo-maxillary joint.

Fig. 2. Portions of the same, showing the temporo-maxillary joint from without, as well as the ligamentous attachment between the skull and the hyoid bone.

Fig. 3. The same from within, omitting the cranio-hyoid attachment.

Fig. 4. The scapular ligaments and the claviculo-scapular attachment.

Fig. 5. The same, viewed from in front, together with an anterior view of the shoulder-joint.

Fig. 6. Sagittal section of the shoulder-joint.

PLATE XXXVIII

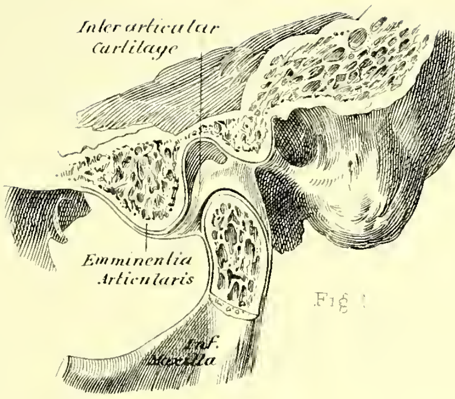


Fig 1

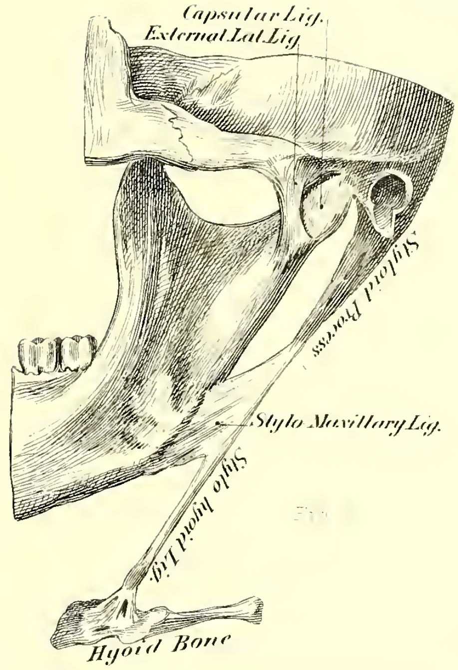


Fig 2

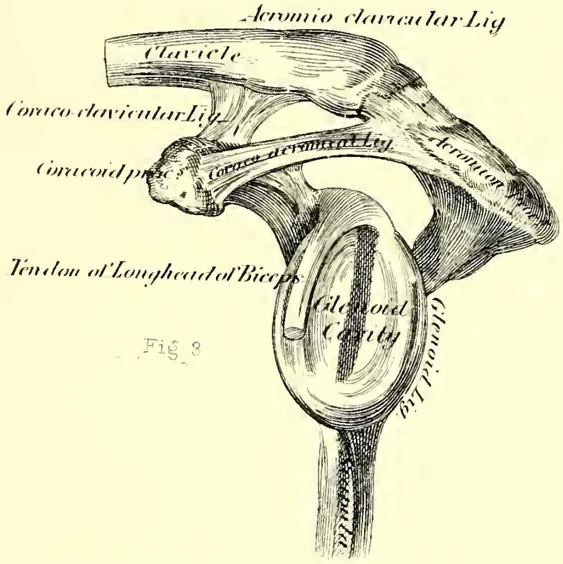


Fig 3

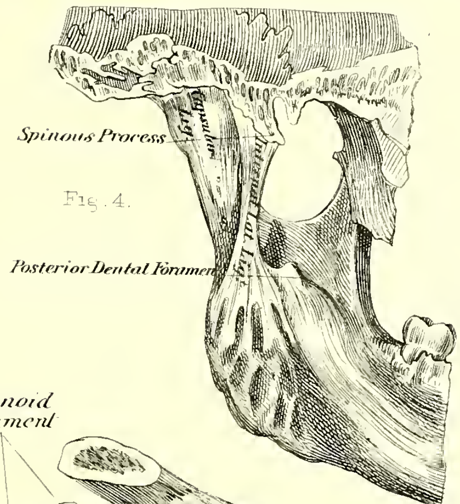


Fig. 4.

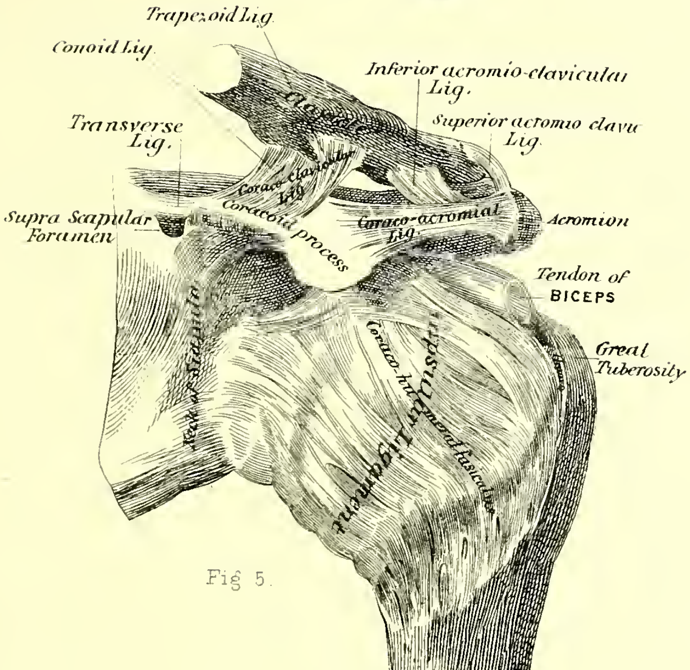


Fig 5.

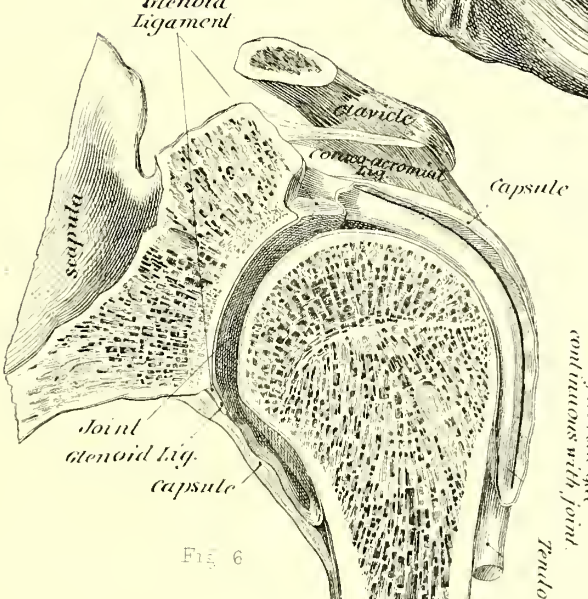


Fig 6

T. Sinclair & Son Lith.

exists between the inferior portion of the thoracic end and the first rib. The symphyseal motion is capable of assuming, under some conditions, a great degree of latitude, owing to the mobility of the interarticular disk. It would be brought greatly into play in the act of swimming. The diarthrodial movements are determined by the actions of the muscles that depress and draw forward or backward the clavicle, as following the forced action of the Pectoralis Major, the Latissimus Dorsi, etc. The movements of symphysis are in a measure checked by the interarticular ligament, while those of diarthrosis are checked by the costo-clavicular ligament.

The claviculo-sternal articulations are of great strength, since upon the maintenance of the clavicle against the sternum depend the movements of the humerus. Luxation of this joint is infrequently seen. The bone may also be displaced upward and, more rarely, backward.

The Joint and Ligaments of the Shoulder.

The region of the shoulder includes the scapular end of the clavicle, the scapula, and the head, neck, and tuberosities of the humerus, together with the soft parts covering the above structures.

The ligaments and the joint structures are as follows:—

The Ligaments of the Scapula.
The Scapular attachments of the Clavicle.
The Shoulder-Joint.

THE LIGAMENTS OF THE SCAPULA.

The ligaments of the scapula are—

The Transverse.
The Acromio-Coracoid.
The Glenoid.

The Transverse Ligament is a delicate band of fibrous tissue, extending across the scapular notch. It arises from the base of the coracoid process, and it is inserted into the external edge of the upper border of the scapula. It consists, as a rule, of two fasciculi, one pertaining to the dorsal, the other to the ventral aspect of the notch.—Usually transverse, the fibres of this ligament may be oblique, and nearly parallel to the axillary border of the scapula, and in part continuous with the fibres of the conoid portion of the coraco-clavicular ligament.

The Acromio-Coracoid Ligament extends as a broad, somewhat triangular ligament between the lateral border of the coracoid process and the tip of the acromion. It is free and thick behind, but tapers in front where it is continuous with a thin layer of connective tissue underlying the Deltoid muscle. It is lost in the connective tissue over the infra-spinous fossa.—According to Henle, the posterior margin of this ligament passes over the supra-spinous fossa. Beneath, the ligament is loosely held to the tendon of the Supra-spinatus muscle and the capsule of the shoulder-joint. The upper surface, from which it is separated by a bursa, is covered by the Deltoid muscle. The outline of the ligament can be felt under the skin.

The acromio-coracoid ligament and the coracoid process and the acromion form a wide though low vault, against which the head of the humerus and the upper portion of the great tuberosity are held during the contraction of the Supra-spinatus muscle and the consequent elevation of the arm.

The Glenoid Ligament is a triangular rim of fibro-cartilage which surrounds the edges of the glenoid fossa. It is usually less thick below than above, where it is in intimate association with the tendon of the Biceps muscle. It is more prominent on the median as compared with the lateral edge, is of a yellow color, and composed of concentrically arranged fibres.

THE SCAPULAR ATTACHMENTS OF THE CLAVICLE.

These are two in number as follows:—

The Acromio-Clavicular Joint.
The Coraco-Clavicular Ligament.

The Acromio-Clavicular Joint.

The Acromio-Clavicular Joint consists of a diarthrodial joint situated between the clavicle and the acromion, and is composed of two obliquely placed opposed facets, the upper of which is derived from the clavicle. Both surfaces are covered with a thin layer of fibro-cartilage. It is subject to much variation in form, and is best developed in muscular individuals.

It presents for examination the following structures:—

The Superior Acromio-Clavicular Ligament.
The Inferior Acromio-Clavicular Ligament.
The Interarticular Fibro-Cartilage.
The Synovial Membrane.

The Superior Acromio-Clavicular Ligament consists of straight fibres extending from the lateral end of the clavicle to the median side of the acromion.

The Inferior Acromio-Clavicular Ligament extends between corresponding points with the superior, and does not require separate description. Some writers

describe the ligaments of the acromio-clavicular joint as constituting a true capsule. Since the facet occupies the posterior part of the scapular portion of the clavicle only, it follows that the ligamentous tissue in advance of the facet is entirely distinct from the joint.—The capsule is composed of a number of straight fibres, embracing the facets, and extending from the lateral end of the clavicle to the median side of the acromion. It is much thicker above than below.

The Interarticular Fibro-Cartilage is rudimental. The capsule sends the disk inward from its under surface. It is rarely sufficiently large to separate entirely the joint surfaces, and may be absent.

The Synovial Membrane resembles the membrane found in other joints. When the interarticular fibro-cartilage is complete, two sacs are formed.

Dislocation of the scapular end of the clavicle is exceedingly difficult to reduce.

The Coraco-Clavicular Ligament.

The Coraco-Clavicular Ligament extends from the clavicle at and near the conoid tubercle to the coracoid process. It is composed of two portions—the conoid and the trapezoid, which are often spoken of as distinct ligaments. The two portions are more or less continuous on the coracoid process, as they converge from the clavicular attachments. The *conoid portion* (conoid ligament) is nearly vertical, and is placed somewhat behind and to the median side of the trapezoid. It is more or less triangular in form, and extends between the conoid tubercle and the posterior border of the scapular end of the clavicle downward, to be attached to the median side of the base of the coracoid process directly in front of the scapular notch. It oftentimes receives a small fascicle from the sheath of the Subclavius muscle. The *trapezoid portion* (trapezoid ligament) extends obliquely from the clavicle downward and inward. It is placed somewhat in front and to the lateral side of the conoid portion, and is attached above to the clavicle from the oblique line on the under surface of the scapular end of the clavicle, and below to the rough surface of the median border of the base of the coracoid process. A bursa is often found between the two ligaments. The subclavicular groove extends a short distance between them.

Movements.—In the acromio-clavicular joint the clavicular facet and the inter-articular disk are relatively fixed; while the scapular facet is circumducted, and responds to all the motions of the scapula. The coraco-clavicular ligament acts as a check to rotation of the scapula, and indirectly relieves the joint from strain. The acromio-coracoid ligament also relieves it, as in the acts of creeping and in pushing downward

THE SHOULDER-JOINT.

The shoulder-joint (scapulo-humeral joint) represents the contact of the head of the bone against the glenoid cavity of the scapula. Both the surfaces are covered with cartilage. That on the humerus is thickest in the middle, and thinnest at the sides; that of the glenoid cavity is thinnest in the middle, and thickest at the sides.

The ligaments of the shoulder-joint are—

The Capsular Ligament.
The Coraco-Humeral Ligament.
The Synovial Membrane.

The Capsular Ligament is a loose capsule of fibrous tissue attached to the neck of the scapula just beyond the brim of the glenoid cavity above, and to the neck of the humerus below. It is notably strengthened externally by a band arising from the base of the coracoid process, and directed toward the greater tuberosity of the humerus, known under the name of the *coraco-humeral ligament*, and in a less degree by the tendons of the Supra-spinatus, the Infra-spinatus, and the Subscapularis muscles. The two muscles last named are remarkable for the intimate manner in which the fibres of the capsule are associated with them. The capsule is weakened at the point of union, and may be defective, as in the instance where the tendon of the Subscapularis and that of the Infra-spinatus lie in contact with it.—The ligament forms a loose vertical fold at the inner side of the neck of the humerus when the arm is in repose. This fold is, however, obliterated when the arm is elevated.—The capsule is sufficiently capacious to hold a body much larger than that of the head of the humerus, and requires the sustained action of the muscles about the joint to keep the head of the bone in position. It is supported within by the long head of the Biceps muscle, which passes over the head of the humerus, and which serves to give it support by the pressure exerted from below upward. It is further strengthened from without by the position of the coracoid process, the acromion, and the coraco-acromial ligament.

The Synovial Membrane of the shoulder-joint sends short prolongations along the course of the Infra-spinatus and the Subscapularis muscles and the defective places in the capsule. A third *cul-de-sac* passes along the entire length of the bicipital groove of the humerus, which is inclosed by a transverse fibrous

band above, and by the fibrous extension of the tendons of the Latissimus Dorsi and the Teres Major muscle at the floor and sides. A delicate fold of the synovial membrane assists the long head of the Biceps muscle in retaining its position in the bicipital groove. Humphry says that the head of the humerus in dislocation of the shoulder is sometimes received within the bulging *cul-de-sac* of the synovial membrane under the Subscapularis.

The Arteries of the joint are branches of the anterior and the posterior circumflex and suprascapular.

The Nerves are branches of the circumflex and the suprascapular.

Remarks.—The movements of the shoulder-joint are so combined with the functions of the shoulder muscle that it is impossible to disassociate them. The chief agency, here as in other diarthrodia, in the maintenance of contact between the humerus and the scapula, is atmospheric pressure. Marked rotation of the humerus outward in the subject will cause separation of the surfaces, when the head of the humerus will fall away from the scapula. Rotation of the arm inward restores the normal contact between the two. This observation, made on the authority of Henke, may be received with a single qualifying fact, that the description is known to be true of the dead subject only.—It is more than probable, even if the original non-elastic muscles about the joint interfere with their physiological uses in maintaining contact, that inward rotation is in many features distinct from outward rotation. The outer (lateral) half of the head of the humerus when covered with cartilage differs from the median. The former is the more convex side of the surface, and ends abruptly at the anatomical neck; the latter, in addition to being flatter, ends imperceptibly at the neck, and is continuous at its borders with the capsule. The line separating these two surfaces is well defined by the coraco-humeral ligament, which answers to the greatest length of the head of the humerus obliquely downward and outward. On the posterior surface of the joint the scapular head of the Triceps lies nearly in a similar line. The muscles strengthening the joint and assisting in maintaining contact are, apart from the scapular muscles proper, the Deltoid, the Biceps, the Coraco-brachialis, the Triceps, and upper part of the Serratus Magnus. Unaided contraction of the Deltoid tilts the head of the humerus downward from the glenoid cavity—in which action the Serratus Magnus and the Pectoralis Major assist.[1]

[1] Duchenne, Physiologie des Mouvements.

The joint is strengthened in such movements by the Coraco-Brachialis, and the scapular head of the Triceps.

For the mechanism between the humerus and the acromion, see W. Ruge.[1]

The Costo-scapular Joint. Under this head Luschka[2] has described a bursa-like joint between the scapula and the third and fourth ribs of the left side. R. Hesse[3] gives a case in illustration of the presence of this joint in a man aged twenty-three, who complained of a grating sensation in moving the left arm, and of slight pain at the junction of the second and third ribs with the sternum. Noisy crepitation was readily observed upon motion of the scapula.

Remarks.—The coraco-clavicular ligament is of enormous strength. It limits rotation of the scapula forward and inward, and is the chief agency by which elevation of the scapula is effected by muscles inserted into the clavicle, namely, the Sterno-Cleido Mastoid and the Trapezius.

The Elbow-joint and Ligaments.

The parts entering into the elbow-joint are the trochlear surface and the radial head of the humerus, the greater and lesser sigmoid cavities of the ulna, and the head and the neck of the radius. These parts are inclosed in a common capsular ligament which is notably thickened at the sides; but it is thin both in front and behind, and is intimately attached to the annular ligament holding the head of the radius in position.

The parts to be studied, therefore, at the elbow-joint are—

The Capsular Ligament.
The Internal Lateral Ligament.
The External Lateral Ligament.
The Orbicular Ligament.
The Synovial Membrane.

The Capsular Ligament is very loose, though on the whole thin and of varying thickness. It extends in front from above the coronoid fossa to the coronoid process and the annular ligament, and behind from above the olecranon fossa to the olecranon. Anteriorly it is stronger at the middle than at the sides, and is covered by the Brachialis-Anticus muscle. Behind it is relatively strong above the tip of the olecranon, but very weak and bursa-like at the side, where it is composed of transverse fibres extending from the ole-

[1] Zeit. für Rat. Med., 1859, 258.
[2] Prager Vierteljahrschr., cvii. 1870.
[3] N. Y. Med. Journ., 1871, 730.

cranon to the lateral margins of the humerus. The interstices between the ulna and radius are filled with fat.

The Internal Lateral Ligament is composed of two fasciculi of diverging fibres, — an anterior and a posterior. The *anterior fasciculus*, the stronger and more superficial of the two, extends between the anterior surface of the epitrochlea and the inner margin of the coronoid process; it serves to limit extension. The *posterior fasciculus*, thin and radiated, extends from the posterior surface of the epitroehlea to the side of the olecranon, and serves to limit flexion. It is directly continuous with the capsule posteriorly. Between these two fasciculi is a minute foramen answering to the notch at the inner end of the transverse groove, which is filled with a pellet of fat. The internal lateral ligament is covered by the common flexor mass. The ulnar nerve is, in a measure, protected by an imperfect fibrous canal, which is covered by the ulnar fibres of origin of the Flexor Carpi Ulnaris muscle.

The External Lateral Ligament is an imperfectly defined thickened band of the capsule, extending from the epicondyle, and spread out over the orbicular ligament, which it holds in position. It is shorter than the internal. Posteriorly a number of its fibres are attached to the ulna. The external lateral ligament is covered by the origin of the common extensor mass, and yields points of origin for the Supinator Brevis muscle.

The Orbicular Ligament (annular, coronary ligament) is a strong ring-like band attached to the anterior and the posterior edges of the lesser sigmoid cavity. It is thicker behind than in front, and thinner above than below, where it ends at the neck of the radius. It describes four-fifths of a circle, and encompasses the vertical surfaee of the head of the radius. It is sustained by the fibres of the external lateral ligament and a portion of the anterior division of the eapsule. At a point where these structures are divided, the annular ligament sinks to the position of the neck of the radius. According to Cruveilhier, the ligament is easily ruptured in front. In luxations it is not the external lateral, but rather the anterior portion of the orbicular ligament that is ruptured.

The Synovial Membrane lines the ulno-humeral as well as the radio-humeral surfaces. Morbid growths developed within the plieæ of this membrane may resemble movable cartilages. Luschka mentions a ease in which a body of this kind placed in the olecranon fossa prevented full extension of the forearm.—The ulnar nerve lies so near the capsule that its section at this point cannot be attempted without endangering the integrity of the joint.

The Arteries are derived above from the communicating branch between the superior and the inferior profunda and the anastomotic branches of the brachial, and below from the recurrent branches of the radial and the ulnar arteries.

The Nerves of the elbow-joint are received posteriorly from a braneh of the ulnar nerve, and anteriorly from a branch of the radial.

MOVEMENTS.—The elbow-joint embraces two lines of movement: a movement of flexion and extension taking place between the trochlea of the humerus and the ulna; and a movement of rotation taking place between the radial head of the humerus, the orbicular ligament, and the head of the radius. The last-named portion of the joint enters into flexion and extension with that of the trochleo-ulnar movements. Flexion is checked by the coronoid process lying within the coronoid depression of the humerus.—Pronation and supination may be demonstrated in extreme flexion, when the motion occurs between the raised rim of the radial proximal surface and the depression above the radial head of the humerus.—Extension is checked by the olecranon lying within the olecranon fossa of the humerus. It is limited by about 180°.—Inward rotation is checked by the lateral border of the vertical surface of the radial head impinging against the anterior portion of the orbicular ligament.—Outward rotation is checked by the oblique ligament and by the median border of the radial head impinging against the orbicular ligament.

The lateral ligaments are of great importance in maintaining the integrity of all parts of the elbow-joint. The joint is destroyed, should one of them be divided.

The bones of the forearm do not coincide with the axis of the arm, either in flexion or in extension. In flexion they incline inward, and in extension outward. The latter inclination is most pronounced in supination. In applying an extending force to the forearm with a view of influencing the shoulder, it is recommended to pronate the hand. In this position the inclination of the forearm outward is measurably removed.[1]

The movements of flexion and extension are performed on paths that are held by H. Meyer[2] to be portions of a screw-like or spiral figure.

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[1] Richet, Anat. Medico-Chirurg., 897.

[2] Arch. f. Anat. Physiol. und Wissensch. Med., 1866.

The Ligaments of the Radius and the Ulna.

The movements of pronation and supination take place between the radius and the hand as one factor, and the humerus and the ulna as the other.

The joints interested in the movements are—

The Humero-Radial.
The Superior Radio-Ulnar.
The Inferior Radio-Ulnar.

The Humero-Radial Joint (figs. 1 and 3, Plate XXXIX.) is a part of the elbow-joint, and has been already described.

The Superior Radio-Ulnar Joint exists between the convex circumferential vertical border of the head of the radius and the concave lesser sigmoid cavity of the ulna. The elbow-joint in great part defines it. It is strengthened by the orbicular and the oblique ligaments.

The Oblique Ligament is a stout band passing obliquely downward and outward from the region of the base of the coronoid process (tubercle) of the ulna to the radius a little distance below the tuberosity. It acts as a check to supination.

THE INTEROSSEOUS MEMBRANE.

The membrane stretching across the space between the radius and the ulna is called the *interosseous membrane.* It is attached by roughened borders, which are specially well marked at the upper portion. Aponeurotic in structure, the membrane is composed of thin fibres directed obliquely downward and inward, while its posterior surface is strengthened by fibres passing in the opposite direction. It imperfectly occupies the interosseous space, since it begins about an inch below the tubercle of the radius, and terminates a short distance above the wrist-joint. It is perforated at several points for the passage of small bloodvessels, and toward the lower border by a larger opening for the posterior interosseous artery.

The interosseous membrane assists the oblique ligament in checking supination. It also acts as an intermuscular septum between the muscles on the anterior and the posterior portion of the forearm.

THE INFERIOR RADIO-ULNAR JOINT.

The head of the ulna is held in the sigmoid cavity of the radius by the anterior and the posterior radio-ulnar ligaments. Between the free distal end of the ulna and the cuneiform bone a plate of fibro-cartilage is inserted.

The several parts of the joint, therefore, are—

The Anterior Radio-Ulnar Ligament.
The Posterior Radio-Ulnar Ligament.
The Fibro-Cartilage.
The Synovial Membrane.

The Anterior and the Posterior Radio-Ulnar Ligaments (figs. 2, 4, and 5, Plate XXXIX.) are straight and narrow bands extending on either side of the radio-ulnar articulation.

The Fibro-Cartilage is of a triangular form, placed transversely to the axis of the forearm. It is thick, and attached by its base to a ridge at the carpal side of the sigmoid of the radius; and by its small extremity to the notch between the head of the radius and the styloid process. It is thin at the sides and centre, where, indeed, it may be perforated, but thick at the apex and the circumference. The apex is a stout ligamentous structure by means of which the cartilage is attached to the ulna. It is concave on both sides—above for the head of the ulna, and below for the cuneiform bone.

The Synovial Membrane between the radius and the ulna is continuous with that between the fibro-cartilage and the head of the ulna. It is known as the *membrana sacciformis*, and is remarkable for containing a relatively large amount of synovial fluid.

The movements of pronation and supination do not affect the ulna when the elbow-joint is extended, but induce a slight rotatory motion, which is best marked at the distal end when the elbow is semi-flexed.

The Wrist-Joint.

The wrist-joint (radio-carpal) (figs. 2, 4, and 5, Plate XXXIX.) is formed by the distal end of the radius, together with the triangular fibro-cartilage articulating with the proximal surface of the first row of carpal bones. — The proximal factor of the wrist-joint is composed of the radius, which forms its outer two-thirds, and of the fibro-cartilage, which forms its inner third. The general surface is concave in both directions, and marked by three impressions: the outer for the scaphoid bone, the middle for the semilunar bone, and the inner for the cuneiform bone. The sides of the concavity are deepened by the styloid processes.—The distal factor is convex in both directions, with an inclination toward the dorsal surface. The joint embraces—

The Capsular Ligament.
The Internal Lateral Ligament.
The External Lateral Ligament.

The Capsular Ligament. The *anterior portion* of the capsular ligament is shorter toward the radial side, and stronger than the posterior. It extends from the lower border of the forearm to the first row of carpal bones — thence a slip is continued to the os magnum. — The *posterior portion* (rhomboid ligament) descends obliquely downward and outward to the first row of bones, the fibres notably converging toward the cuneiform bone.

The Internal Lateral Ligament passes as a firm cylindrical cord from the spinous process of the ulna to the cuneiform bone, at the same time sending fibres to the pisiform bone and the anterior annular ligament. It is partially covered by the Extensor Carpi Ulnaris muscle.

The External Lateral Ligament, stouter though less defined than the preceding, passes from the styloid process of the radius to the scaphoid bone, where it effects a broad attachment. It contributes to the composition of the anterior annular ligament, and thence is continued to the trapezium. Its lateral side is in relation with the Extensor Ossi Metacarpi Pollicis muscle.

The Synovial Membrane is loose behind. At times the cavity is continuous with the pisiform articulation, and at others, through the absence of one of the interosseus ligaments of the first row, with the intercarpal synovial sac.

The wrist-joint is in a line with the apex of the styloid process of the ulna.

The Joints and the Ligaments of the Hand.

These comprise—

The Joints and Ligaments of the Carpus.
Those of the Carpo-Metacarpal Joint.
Those of the Inter-Metacarpal Joints.
Those of the Metacarpo-Phalangeal Joints.
Those of the Inter-Phalangeal Joints.

The Joints and Ligaments of the Carpus include the structures uniting the bones in each row, and those that unite the two carpal rows.

The bones of the first row of the carpus are united on the dorsal surface by a ligament placed between the scaphoid and the semilunar bones, by one between the semilunar and the cuneiform, and by a third—an interosseous ligament—placed near the dorsal surface, and uniting the last-named bones.

On the palmar surface the bones are united by three bands, stretching from the scaphoid to the semilunar bones, and from the semilunar to the cuneiform.

The bones of the second row are united by similar bands to the foregoing, situated on the dorsal and the palmar surfaces. These pass between the os magnum and its associated bones, the trapezoid bands being especially powerful. The pisiform bone is remarkable among its fellows in being isolated from the synovial membrane of the rest of the carpus. The bone is held to the ulna by the internal lateral ligament, and to the fifth metacarpal bone and the hooked-process of the unciform bone by three stout ligaments.

Viewed as a whole the ligaments of the carpus are stronger where they unite the bones of the rows than where they unite the parts of the intercarpal joint. The ligaments of the ulnar side are stouter than are those of the radial.

The joint between the two carpal rows is convex on its proximal surface, where for the radial third it is composed of the distal surface of the scaphoid bone, and concave for the ulnar two-thirds through the lateral surface of the scaphoid bone, and the distal surfaces of the semilunar and the cuneiform bones. The distal surface is concave at the lateral (radial) third, where it is made up by the proximal facets of the trapezium and the trapezoid bone; it is convex at the median (ulnar) two-thirds where the distal surfaces of the os magnum and the unciform bones unite to form it. The last-named portion presents well-defined lateral facets.

The two rows are united on the palmar surface by an external lateral ligament extending between the scaphoid and the trapezium, as well as by a second

EXPLANATION OF PLATE XXXIX.

Fig. 1. The elbow-joint, seen from in front.
Fig. 2. The wrist-joint, seen from in front.
Fig. 3. The elbow-joint, seen from the median side.
Fig. 4. The wrist-joint, seen from behind.
Fig. 5. The carpal and metacarpo-phalangeal synovial sacs.

PLATE XXXIX

Fig 1

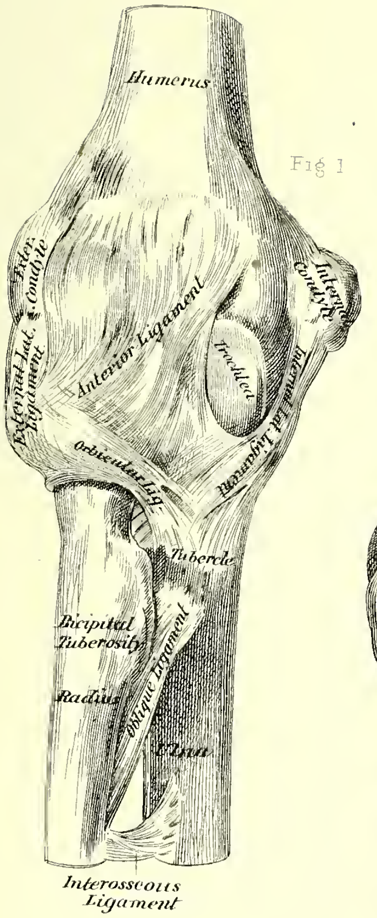


Fig 2

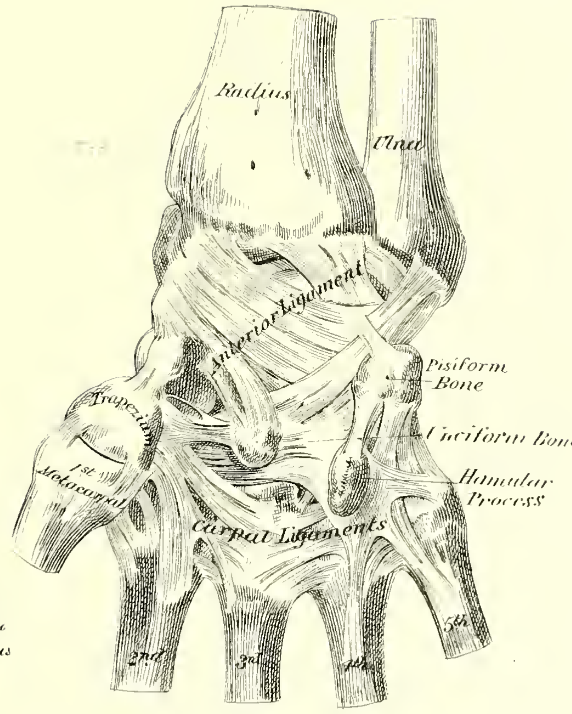


Fig 3

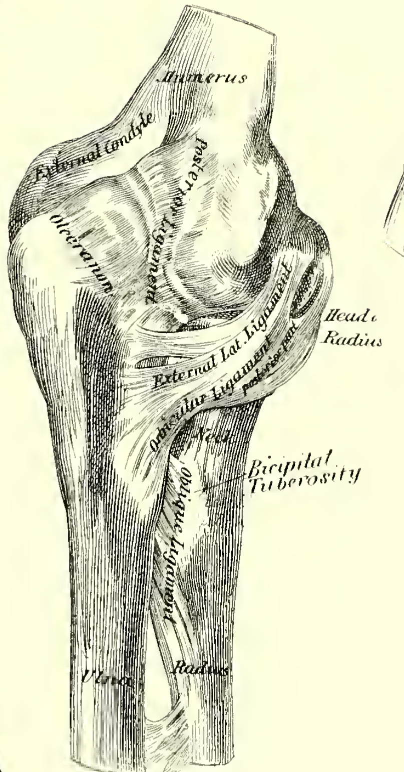


Fig 4.

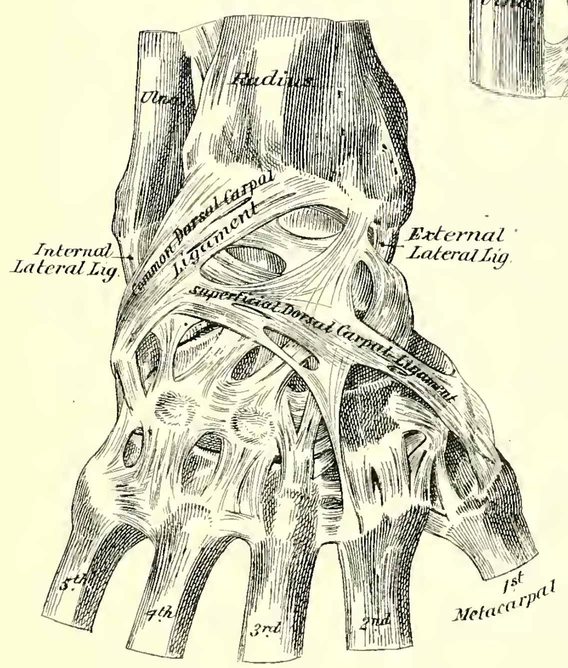
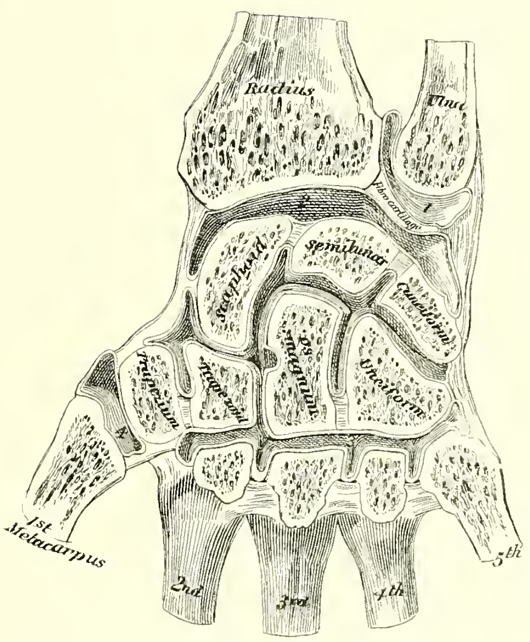


Fig 5



T. Sw... & Son, Lith.

ligament extending obliquely downward and inward from the scaphoid bone to the os magnum. On the dorsal surface two oblique ligaments pass between the cuneiform bone to the unciform; one from the semilunar bone to the os magnum; another from the scaphoid bone to the os magnum (this acts as an interosseous ligament, separating the lateral from the median portion of the joint); and yet another from the scaphoid bone to the trapezoid bone.

The Synovial Membrane of the intercarpal articulation sends processes upward between the bones of the first row and downward between those of the second, and communicates with the sac between the second row and the metacarpal bones.

The median border of the carpus is strengthened by the external lateral ligament of the wrist-joint.

Movements.—The joint between the two rows is freely movable in flexion and extension. The high degree of specialization noted in the formation of the thumb and index finger is correlated with the forms of the joints intervening between them and the forearm. The lateral third of the joint is restricted to the movements of the first row of carpal bones upon the trapezium and the trapezoid, these bones being in longitudinal serial union with the thumb and the index finger.—The largest surface of contact between the two rows occurs when the second row is strongly extended on the first, as in the act of supporting the body on the hand in creeping.—The median two-thirds of the joint, in addition to flexion and extension, permit a greater degree of locking to occur than in the lateral third.—The lateral facets of the socket-like proximal surface act as supporting or check facets at the limits of pronation and supination.—The interosseous ligament between the scaphoid bone and the os magnum acts as a check to pronation.—The carpus when at rest presents the second row of bones moderately extended upon the first. This is the position instinctively taken after injury of the wrist or body of the hand, and is the one to which surgical appliances should be adapted.

The Nerves of the Carpus. The dorsum is supplied by a branch of the radial nerve; the ulnar aspect, by the interosseous nerve and a recurrent branch of the ulnar nerve; the radial side by a deep branch of the ulnar. The metacarpo-phalangeal and the inter-phalangeal joints are supplied by the ulnar nerve.

The Arteries are derived from the anterior and the posterior branches of the radial and the ulnar, as well as from the interosseous artery and the deep palmar arch.

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THE CARPO-METACARPAL AND THE INTER-METACARPAL JOINTS AND LIGAMENTS.

These lines of union are conveniently considered together. Two distinct joints are formed between the surfaces embraced in the title,—one between the first metacarpal bone of the thumb and the trapezium, and one between the remaining metacarpal bones and the trapezoid bone, the os magnum, and the unciform bone.—The first-named joint is saddle-shaped, provided with a loose but stout capsule, strengthened by two lateral ligaments. The outer of these arises from the proximal end of the second metacarpal bone.—The second-named joint is nearly flat or sinuate between the os magnum, the unciform, and the third, the fourth, and the fifth metacarpal bones, but more irregular and angulated between the trapezoid bone, the trapezium, and the second metacarpal bone. The joint is usually strengthened above by two ligaments to each metacarpal bone and below by numerous bands.

The fifth metacarpal bone is united to the unciform by capsule-like bands, recalling the peculiarities of the joint between the first metacarpal bone and the trapezium.—Interosseous ligaments unite the os magnum and the unciform bone with the third and the fourth metacarpal.—An intermetacarpal ligament passes between the third and the fourth metacarpal bones.—A special palmar ligament extends distally and medianly, to unite the trapezium with the third metacarpal bone.

Movements.—The joint between the first metacarpal bone and the trapezium, like saddle-joints elsewhere, permits of free motion in all directions.—The joint between the remaining metacarpal bones and the trapezoid, the os magnum and the unciform bone, is more fixed, but is quite mobile at the fourth and fifth metacarpal bones as compared with that at the second and third.—The capsule-like ligament at the fifth metacarpal bone enables a greater degree of motion to be here displayed than at any other portion of the carpo-metacarpal line.—The least degree of motion takes place at the second metacarpal bone.—The interosseous ligaments act as checks to extremes of movement of flexion and extension.—The fourth and the fifth metacarpals move together upon the nearly fixed third bone.

THE METACARPO-PHALANGEAL JOINT.

The distal extremity of each metacarpal bone presents a large convex surface that is wider below than above, and is joined to a small concave surface on the proximal end of the first phalanx.

The surfaces are united by a capsular ligament which presents the following subdivisions:—

The Anterior Ligament.
The Posterior Ligament.
The two Lateral Ligaments.
The Transverse Ligaments.

The Anterior Ligament (glenoid ligament) is a thickened pad that forms on the palmar surface a firm concavity, in which lie the flexor tendons of the fingers. The sheath of the tendons is closely incorporated with the pad. Its posterior surface is also concave, to receive the palmar aspect of the head of the metacarpal bone.

The Posterior Ligament is weak, bursa-like, and is protected by the tendon of the common extensor.

The Lateral Ligament extends obliquely from the posterior tubercle of the lower end of the metacarpal bone to the anterior tubercle of the proximal end of the first phalanx. It is a powerful ligament, the external being the stronger, though less strong than is the same structure between the phalanges. It is stretched by flexion, and relaxed by extension.

The plan of the metacarpo-phalangeal joint of the thumb recalls that of an inter-phalangeal joint in presenting a small anterior pad, in possessing lateral ligaments, and in retaining the phalangeal character of both articular facets.

The Transverse Ligaments, four in number, unite by loose broad bands the heads of the four median metacarpal bones. They can be felt in the undissected hand beneath the skin of the interdigital spaces.

According to Holden, a furrow of the palm, running transversely across the lower third, "corresponds pretty nearly with the metacarpal joints of the fingers, with the upper limit of the synovial sheaths of the fingers (that of the little finger excepted); also with the splitting of the palmar fascia into its four slips." The transverse metacarpal ligament lies in the same line with the joint. A little below the skin-furrow the digital arteries bifurcate to run along the sides of the fingers.

THE INTER-PHALANGEAL JOINTS AND LIGAMENTS.

The plan of these joints is so similar to the foregoing as not to need a detailed description. The distal surface of each joint is depressed toward the sides and raised in the middle, while the proximal surface is raised at the sides and depressed in the middle. This peculiarity is least marked in the joint between the second and the third phalanges. Exceedingly stout lateral ligaments strengthen each joint that is otherwise unprotected save on the palmar surface where a fibro-cartilaginous pad is seen. Over this structure the tendons of the flexor muscles play.

MOVEMENTS.—Flexion and extension are here alone possible. A slight degree of rotation is secured by manipulation.

Prof. Cleland[1] has described stout ligamentous structures extending from the sides of the phalanges, to be inserted into the skin. He assumes that such bands aid in retaining the different parts of the integument in the positions which they are adapted to occupy.

The inter-phalangeal joints correspond to the "knuckles." The line of each joint lies immediately in advance of the main prominence of the "knuckle" in flexion, and of the transverse concave skin-grooves in extension.

THE JOINTS AND LIGAMENTS OF THE LOWER EXTREMITY.

The Joints and Ligaments of the lower extremity embrace the following:—

Those of the Pelvis.
Those of the Hip.
Those of the Knee.
Those of the Leg.
Those of the Ankle.
Those of the Foot.

THE JOINTS AND LIGAMENTS OF THE PELVIS.

The bones of the pelvis are held together by four joints and their respective ligaments.

The joints are as follows:—

The Ilio-Sacral
The Symphysis Pubis.
The Sacro-Coccygeal.

THE ILIO-SACRAL JOINT.

The two Ilio-Sacral Joints are of the nature of symphysis, and in each instance are formed by the apposition of the auricular facet of the innominate bone against the lateral surface of the sacrum, a thin disk of fibro-cartilage intervening. This disk is friable, and frequently possesses a small cavity containing a glairy fluid.

The ligaments of the ilio-sacral joint are—

The Ilio-Lumbar.
The Anterior Ilio-Sacral.
The Posterior Ilio-Sacral.

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[1] Journ. of Anat. and Phys., 1878, 526.

The Ilio-Lumbar Ligament (figs. 1 and 2, Plate XXXIX.) is a stout rounded cord extending from the tip of the transverse process of the last lumbar vertebra to the crest of the ilium.

The Anterior and the Posterior Ilio-Sacral Ligaments are thin layers of fibrous tissue extending from the sacrum to the ilium. Some of these bundles are transverse, others are oblique. The latter are arranged in two fasciculi, the upper extending from the posterior superior spinous process of the ilium to the sacrum; the lower extending from the posterior inferior spinous process of the ilium to the sacrum. Of the two ligaments the posterior is the stronger.

The sacro-iliac junction is easily destroyed by crushing violence. It is thus often involved in fractures of the pelvic bones, when its surfaces have been known to be separated to the distance of two fingers' breadths. Destructive inflammation with suppuration is asserted by Sayre [1] to be a common disease of this articulation, and is invariably of traumatic origin.

Accessory to the ilio-sacral joint are the following ligaments:—

The Greater Sacro Sciatic.
The Lesser Sacro-Sciatic.

The Greater Sacro-Sciatic Ligament is a broad membrane-like structure extending from the outer portion of the tuberosity of the ischium to the upper posterior portion of the ilium, and the posterior lateral surface of the sacrum. It is slightly contracted in the middle, but expanded toward either end. Its fibres are pierced here and there by minute bloodvessels, and are more or less continuous below with the origin of the Semi-Membranosus muscle and the long head of the Biceps Flexor muscle, and above with the iliac fibres of origin of the Gluteus Maximus muscle.

The ligament converts the great sciatic notch into a foramen, and gives origin to some fibres of the Gluteus Maximus.

The inner surface of the ligament at its ischiatic attachment is continuous through the so-called *falciform process* with the obturator fascia covering the internal obturator fascia, and in like manner with lower fibres entering into the sub-pubic ligament.

The great sacro-sciatic ligament should be associated with the deep fasciæ rather than with true ligaments. It is made tense by action of the Biceps Flexor muscle, and may be considered mainly in the light of an aponeurosis.

[1] Orthopedic Surgery, etc., 327.

The Lesser Sacro-Sciatic Ligament extends between the posterior surface of the spine of the ischium and the sacrum, where some of its fibres are continuous with the Ischio-Coccygeal muscle. It converts the lesser sciatic notch into a foramen.

The greater and the lesser sciatic foramina transmit the following structures: the greater, the Pyriformis muscle, the sciatic and the pudic nerve; the lesser, the Internal Obturator muscle, and the internal pudic nerves and bloodvessels.

THE OBTURATOR MEMBRANE.—In addition to the above structures the innominate bones exhibit a firm membrane, occupying the foramen of the same name, which has received the name of the Obturator Membrane. It is pierced near its lower border by the obturator vessels and nerves, and yields surfaces of origin for the Internal and the External Obturator muscles.

THE SYMPHYSIS PUBIS.

The Symphysis Pubis (figs. 3 and 4, Plate XXXIX.) is a joint belonging to the order of symphysis, as the name expresses. Like all the members of this group it possesses an inter-articular disk of fibro-cartilage. Owing to the somewhat bevelled appearance of the median articular surfaces of the pubic bones, a V or Y shaped interval results as they approach one another. The fibro-cartilage of necessity takes the shape of this interval, and is further peculiar in being composed chiefly of cartilage in the basal portion of the V or Y, and of fibro cartilage in the expanded portion. Moreover, the lateral portions of the disk are in intimate union with the tit-like eminences on the pubic surfaces, and retain this connection even after maceration. Not only is the yielding centre of the disk the least fixed of the parts, but it is occupied by a synovial sac. This, in the young of both sexes, and in the male adult, is placed at the basal part of the V or in the stem of the Y, and extends thence forward barely to the centre of the joint. It averages in the adult male a size not greater than that of a split pea. The sac is larger in adult females, and in the parturient may involve the entire thickness of the joint. A moderate degree of motion is possible between the innominate bones during pregnancy and parturition.[1] The position of the symphysis can be felt from within the vagina.

The symphysis is strengthened by accessory fibres

[1] See in this connection J. M. Duncan, Edin. Med. Journ., 1855.

both in front and behind. Those in front are called the Anterior Pubic Ligaments; and those behind the Posterior Pubic Ligaments, and are unimportant. A slender band passing over the tops of the pubic bones has received the name of the Superior Pubic Ligament. A more important arrangement of fibres than the above, is the Sub-Pubic Ligament. It occupies the upper narrowed portion of the sub-pubic arch, and is composed of an intricate interlacement of fibres, which results in the formation of a stout membrane. It is attached above to the under surface of the symphysis, but below is free.

THE SACRO-COCCYGEAL JOINT.

The Sacro-Coccygeal Joint is of the same nature as the intervertebral disks, and does not demand a separate description. The joint is supported by anterior and posterior bands that have received the names of the Anterior and the Posterior Sacro-Coccygeal Ligaments.

THE HIP-JOINT.

The hip-joint (fig. 1, Plate XLI.) serves to hold the innominate bone and the femur together. It belongs to the enarthrodia, and consists of the acetabulum, the head of the femur, and associated ligaments.

The cartilage lining the acetabulum is thicker at the margins than at the centre, while the cartilage covering the head of the femur is thicker at the centre than at the sides. These surfaces are thus mutually adapted.

The following ligaments are described in connection with the hip-joint:—

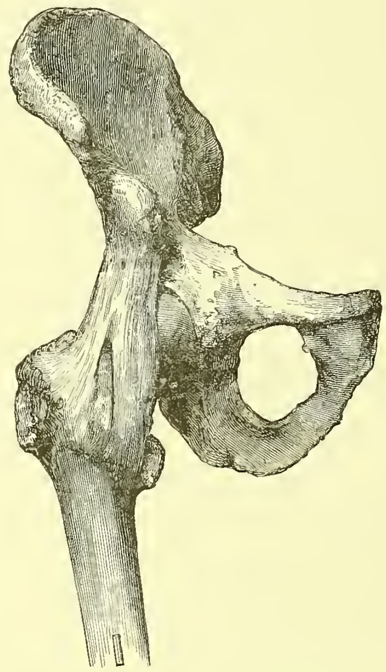
The Cotyloid.
The Transverse.
The Capsular.
The Ligamentum Teres.
The Synovial Membrane.

The Cotyloid Ligament is a prismoid elevation of fibro-cartilage whose base corresponds to the osseous lips of the acetabulum. It assists in deepening the socket, while slightly narrowing it at the rim. It is thinner at the anterior and at the posterior borders than elsewhere, and is composed of freely interlacing fibres that ascend obliquely from the bone.

The Transverse Ligament is a simple band of fibro-cartilage extending between the opposite borders of the cotyloid notch. It converts the notch into a foramen, through which bloodvessels and nerves pass into the joint.

The Capsular Ligament is attached above to the innominate bone, and to the transverse and the cotyloid ligaments. Below it terminates at the spiral line of

Fig. 76.



The hip-joint seen from in front. It is dissected to display the ilio-femoral fascicle.

the femur anteriorly, to the lower third of the neck posteriorly, as well as to the bone at points intermediate between these. The capsule is much thicker at the upper, the outer, and the anterior portions than at the inferior and the inner, where it is thin and weak. The fibres are arranged in oblique, longitudinal, and circular bundles. Of these the longitudinal are the

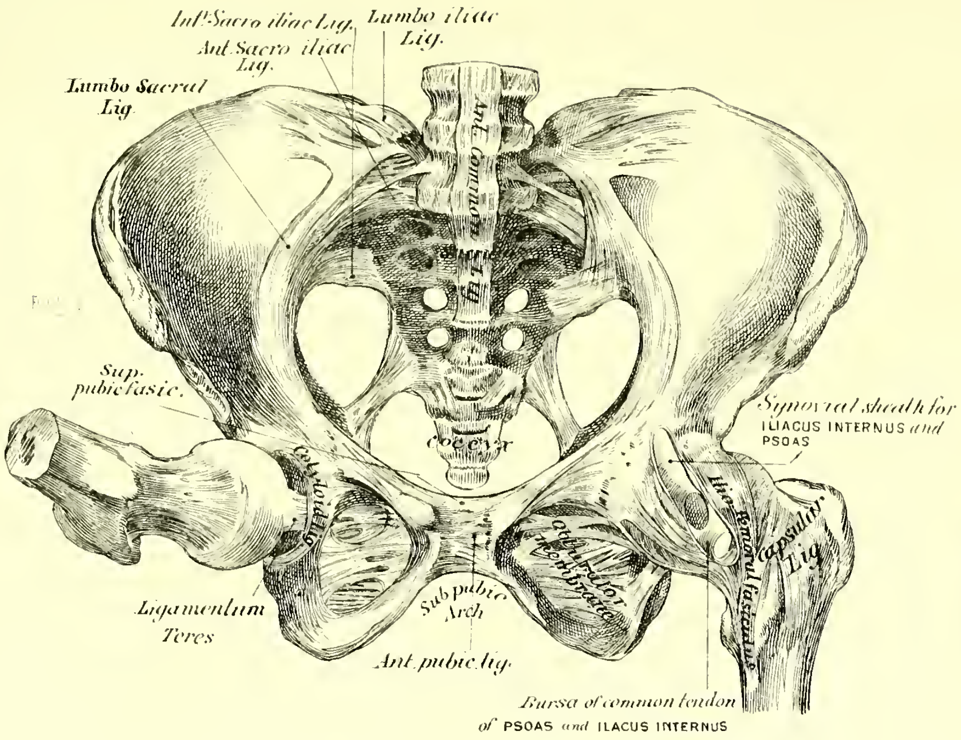
EXPLANATION OF PLATE XL.

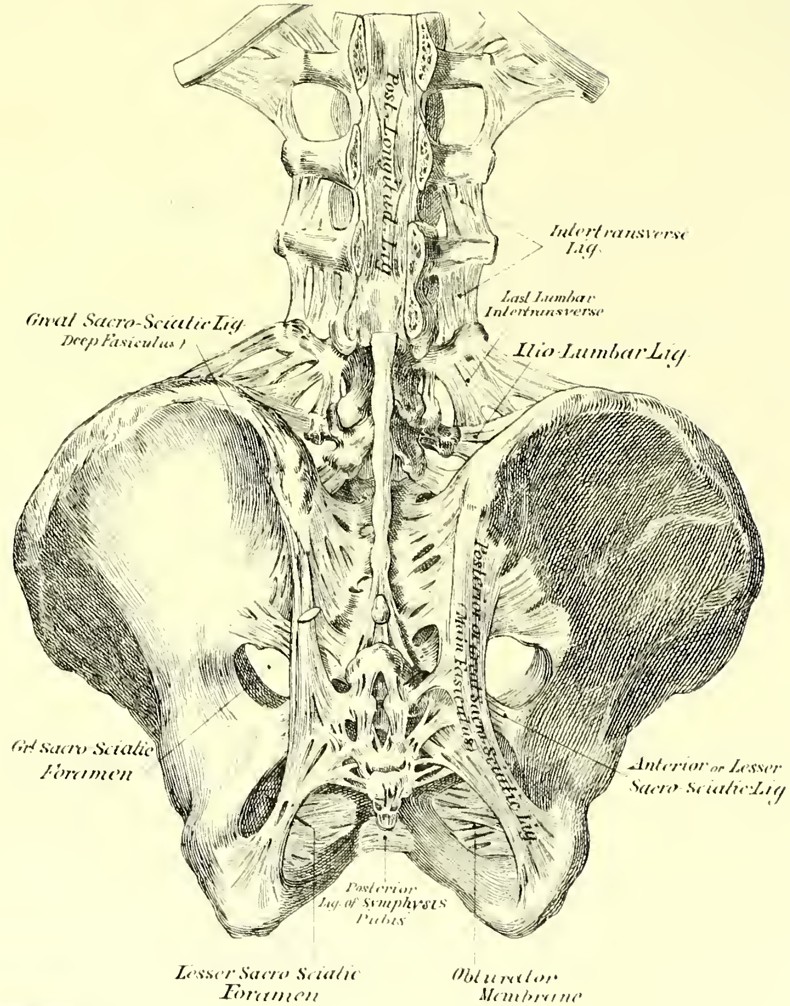
Fig. 1. The ligaments of the pelvis and of the hip-joint, seen from in front.

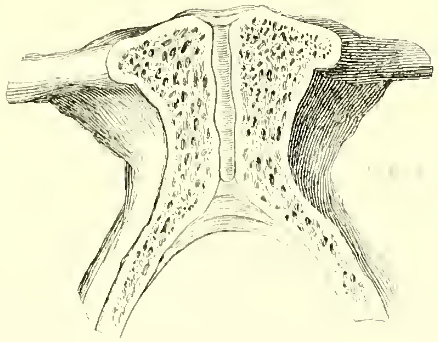
Fig. 2. The ligaments of the pelvis, seen from behind.

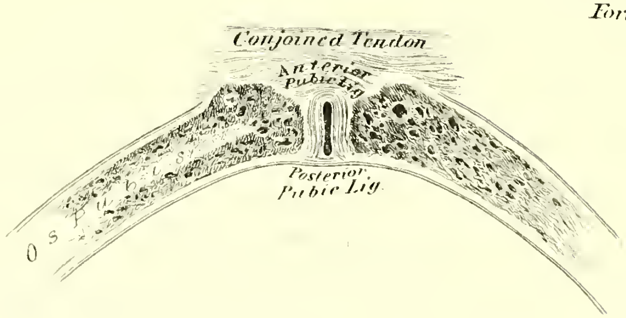
Fig. 3. A frontal section of the symphysis pubis.

Fig. 4. A horizontal section of the symphysis pubis.


Infr Sacro iliac Lig.
Lumbo iliac Lig.
Ant. Sacro iliac Lig.
Lumbo Sacral Lig.
Ant. Common Lig.
Coccyx
Sup. pubic fasic.
Cotyloid Lig.
Ligamentum Teres
Sub pubic Arch
Ant. pubic lig.
Obturator membrane
Synovial sheath for ILIACUS INTERNUS and PSOAS
Ilio femoral fasciculus
Capsular Lig.
Bursa of common tendon of PSOAS and ILACUS INTERNUS


Post. Longitud. Lig.
Intertransverse Lig.
Last Lumbar Intertransverse
Great Sacro-Sciatic Lig. Deep Fasciculus)
Ilio Lumbar Lig.
Posterior or Great Sacro Sciatic Lig (Main Fasciculus)
Grt Sacro Sciatic Foramen
Anterior or Lesser Sacro Sciatic Lig
Posterior Lig. of Symphysis Pubis
Lesser Sacro Sciatic Foramen
Obturator Membrane




Conjoined Tendon
Anterior Pubic Lig
Posterior Pubic Lig.
Os Pubis

PLATE

most important, and extend for the most part along the front of the joint.

A superficial fascicle of great strength (ilio-femoral or Y-shaped ligament), triangular in form, with its base directed downward, is attached above to the anterior inferior spinous process of the ilium, to the space between it and the rim of the acetabulum. It passes downward and outward, and finally bifurcates at the neck of the femur, one bundle going to the spiral line, the other to the depression in front of the lesser trochanter. (See Fig. 76.) In the interval between these branches the deep layer of fibres of the capsule is seen. The anterior surface of the capsule is in close relation with the Gluteus Minimus muscle, and less intimately with the reflected tendon of the Rectus Femoris, and the conjoined tendon of the Iliacus Internus and Psoas Magnus. Between the ligament and the last-named muscles a bursa is seen, which often communicates with the interior of the joint.

The ischio-capsular (ischio-femoral) bundle is attached above to the ischial rim of the acetabulum and the smooth surface between it and the great sciatic notch. The fibres pass horizontally outward, and are lost in the capsule.—A small accessory fascicle, the so-called pubo-capsular ligament (pectineo-femoral) is attached beneath the Pectineus muscle from the pubic border of the obturator foramen or the cotyloid notch, and extends thence to the capsule.—A process of the iliac fascia is detached opposite the pectineal eminence, and passes between the Iliacus Internus and the Pectineus muscle to the capsule.—At points between the above-mentioned fascicles the capsule is weak, and composed of circular and oblique fibres. Of these the circular are the most important. They are especially well developed behind, where they embrace the neck of the femur, and run parallel to the fibres of the Internal Oblique muscle, forming a collar-like band about its lower third, but without attachment to the bone. The synovial membrane is reflected from the femur to the capsule at this point.

The Ligamentum Teres is not round, as the name would imply, but flat. It arises from the edges of the cotyloid notch by two distinct fascicles, which are attached to the transverse ligament, and by a third less defined root, which is derived from the border of the depressed base of the acetabulum that supports a cushion of fat. The ligament ascends round the head of the femur, to be attached to a depression a little below the centre. The ligamentum teres is broader and more compact at its upper than at its lower attachment. It tends to check rotation outward in the flexed position.

The Synovial Membrane is in contact with the opposing surfaces, encloses the round ligament, and is supported by the lower and inner parts of the capsule.

Movements.—The movements of the hip-joint consist of extension, flexion, adduction, abduction, and rotation. The terms eversion and inversion, while referring to the limb as a whole, are determined by the hip-joint. *Eversion* of the limb corresponds to extension with rotation outward, *inversion* to extension with rotation inward. Rotation is naturally less exact when the joint is extended than when it is flexed, since in the first-named position the movement is restricted by the tense ilio-femoral fasciculus, while in flexion the relaxed capsule and the tense ligamentum teres—in the event of flexion being combined with rotation outward—alone restrict it. Extremes of rotation upward are checked by tension of the lower part of the capsule as well as by the contact of the lower border of the neck against the upper margin of the acetabulum.—Extreme of rotation downward brings the most convex portion of the head against the shallowest part of the socket. The movement is checked by the ilio-femoral fasciculus.

Dislocations of the hip will be determined by the ineffective resistance presented in the checks to the various movements of the joint. It will require a greater force to effect dislocation in extension than in flexion, and in flexion with adduction than in flexion with abduction.

In addition to the above elementary statement of the hip-joint movements, the following more elaborate description is herewith presented.

Extension is effected by the head of the femur being thrown forward, and one-half of its anterior surface, viz., that answering to the anterior aspect of the neck, brought out of the acetabulum, while a small portion of the under and posterior surface lies within that cavity. In extension the ilio-femoral fasciculus is tense.

Flexion is the reverse of the above-named movement. The anterior aspect of the head and a small portion of the neck now recede within the acetabulum, while the upper and posterior parts are brought out. In flexion the ischio-femoral fasciculus is tense, and the ilio-femoral relaxed. In flexion combined with adduction the lower portion of the head passes well within the acetabulum, but is free near the neck else-

where. The ligamentum teres is tense. In flexion combined with abduction the head passes entirely within the socket superiorly, but inferiorly is brought out, and is supported by the lower and the inner part of the capsule, which is now tense, while the ligamentum teres is relaxed.

It follows, from what has been seen of the relative degrees of strength of the parts of the capsule, that the joint is best protected in the position of extension, and least so in the position of flexion with abduction.

Rotation is defined in two ways,—rotation with extension, and rotation with flexion. The first-named is necessarily limited, since it takes place while the powerful ilio-femoral ligament is tense. In the living subject it is best measured by the arc of movement of the great trochanter. Rotation with flexion is free in all directions save that of flexion with adduction, which is checked by the tension of the ligamentum teres.

The extreme of upward movement is checked by tension of the lower part of the capsule as well as by contact of the lower border of the neck against the upper border of the acetabulum. The extreme of downward movement is checked by the forced contact of the head against the most convex portion of the tense ilio-femoral fasciculus.

Rupture of the ilio-femoral fasciculus would cause dislocation on extension of the joint, as in the act of standing erect. A wrench of the femur downward and backward while the thigh is raised, and the joint flexed, would cause dislocation, since in this position the weight is thrown against the weak posterior and under part of the capsule. The liability to luxation is increased if the joint is adducted.

An exact knowledge of the actions of the ilio-femoral fasciculus in retaining the head of the femur in its false positions during dislocation has been shown by Dr. H. J. Bigelow[1] to be of great importance. This observer has found the external branch of the fasciculus in dorsal dislocation to hold the limb in an inverted position. Should eversion exist with this dislocation, the external branch of the ligament is ruptured. In anterior oblique dislocation the head of the femur is hooked over the ligament, which is entire. In supra-spinous dislocation the head, as in the preceding example, is hooked over the ligament, but the external branch is ruptured. In pubic dislocation the range of the femur upon the pubes is limited by the ligament, which in the sub-spinous dislocation also binds the neck of the femur to the pelvis. In the thyroid dislocation the limb is everted by the agency of the ligament, and the trochanter rests upon the pelvis. In dislocations which are the result of extreme force the ilio femoral fasciculus is ruptured.

[1] The Hip.

Congenital dislocation of the hip, by altering the lines of pressure of the trunk upon the inferior extremity, induces pronounced anterior inclination of the pelvis, a condition which acts indirectly as a cause of antero-posterior curvature of the lumbar vertebræ.

The cervical portion of the capsular ligament is subject to many variations. It has been found by Dr. G. K. Smith[1] that the ligament may be attached to the neck nearer the head in some subjects than in others.

The hip-joint receives Nerves on the posterior surface from the ischiatic nerve as it supplies the Gemellii and the Quadratus Femoris muscles, and on the anterior surface from a branch of the obturator nerve.

The Arteries giving branches to the hip-joint are the internal circumflex, the gluteal, the obturator, and the sciatic.

The Knee-Joint.

The knee (figs. 2, 3, 4, Plate XLI.) is the largest and most complicated joint in the body. It is composed of the femoral condyles, the tibial condyloid surfaces, and the patella, together with a pair of inter-articular disks, the whole being bound together with appropriate ligaments.

The joint thus presents for examination—

The Capsular Ligament.
The External Lateral Ligament.
The Internal Lateral Ligament.
The Inter-Articular Cartilages.
The Transverse Ligament.
The Crucial Ligaments.
The Synovial Membrane.

The Capsular Ligament is united to the margin of the glenoid cavities of the tibia below, and the tuberosities and lower portion of the popliteal surface of the femur above. It is in addition attached to the margin of the patella and to the patellar ligament in front, as well as to the outer broad surfaces of the semilunar cartilages at the sides. It is of unequal strength and thickness, being strong behind, but weak in the neighborhood of the patella. It is incorporated behind with the tendon of the Semimembranosus muscle, at the side with the lateral ligaments, at the front

[1] The Insertion of the Capsular Ligament of the Hip-Joint and its Relation to Intra-Capsular Fracture. Pamphlet. New York, 1862.

and the inner side with an aponeurotic expansion from the Vastus Internus and the Sartorius muscles, and at the front and the outer side with an expansion from the fascia lata.

The capsular ligament is strengthened by the *ligamentum patellæ*—a structure representing the tendon of the Quadriceps Extensor muscle as it lies between the patella above and the tubercle of the tibia below. It is slightly broader at its upper than at its lower attachment, and is continuous at its outer margin with the capsule. Between the ligament and the skin is lodged a quantity of fat, while between the ligament and the tibia lies an important bursa. Behind, the thick, flat, and unyielding capsule (here often called the Ligamentum Winslowi) is composed for the most part of vertical fibres, which are to some degree in association with the tendons of the Gastrocnemius, the Popliteus, and the Plantaris muscles. A well-defined superficial oblique bundle (oblique fasciculus), which serves as a reflection of the tendon of the Semimembranosus muscle, is directed upward and outward.

Under the name of the *ligamentum arcuatum* is described a fascicle which is attached above at the outer femoral condyle, and below to the inter-condyloid fossa beneath the oblique bundle. The deepest portion of this accession answers to the capsule, as it covers the bursa lying beneath the tendon of the Popliteus muscle. At its lower border the fascicle receives some of the fibres of the Popliteus muscle, as well as a few ligamentous bands attached below to the head of the fibula between the insertion of the Biceps and the origin of the Soleus muscle.

Notwithstanding its great strength the posterior portion of the capsule will yield to pressure from an abscess or aneurism. In this manner pus or blood may reach the interior of the joint from the ham. Of the former lesion J. Adams[1] reports an example. In the course of the treatment of an abscess which had been opened through the skin this writer observed that the pus ceased flowing at a time coincident with swelling of the joint. A free incision being made, a quantity of pus escaped from the interior of the joint, and an opening was discovered in the posterior capsular fibres, by means of which the abscess in the ham had communicated with the joint. Both the Ligamentum Winslowi and the popliteal artery have been ruptured by the fall of a sack of wheat on the thigh.

The External Lateral Ligaments are two in number—the long and the short ligament. The *long ligament* is a stout rounded cord extending from a small prominence situated above the sulcus, near the Popliteus muscle, and in front of the point of origin of the outer head of the Gastrocnemius. It passes downward on the line of the fibula, and is attached to the outer part of the head of that bone. A bursa is often seen between it and the tendon of the Biceps. The ligament closely resembles the last-named tendon, and passing as it does along its anterior border may be confounded therewith. Inferiorly it becomes united with the tendon, and sends an expansion to the patella.

The *short external lateral ligament* is a fasciculus, variable in size, attached above to the outer femoral tuberosity, and passing downward and outward to the styloid process of the fibula. It is often connected with the tendon of the Popliteus muscle, and may end either on the capsular ligament or the tibial aponeurosis.

The Internal Lateral Ligament is a broad membranous expansion passing from the inner femoral condyle from a point below the tubercle for the attachment of the Adductor Magnus muscle, downward and outward to be attached to the corresponding tuberosity and the anterior surface of the shaft of the tibia. Superficially the ligament, as it lies on the tibia, is in relation with the aponeurotic structures of the tendons of the Sartorius, the Gracilis, from which it is separated by a bursa, and the Semitendinosus muscles, and, on a deeper plane, with the aponeurosis of the Vastus Internus muscle. Beneath lies a considerable portion of the Semimembranosus muscle. The deeper fibres of the ligament are attached to the posterior part of the corresponding interarticular cartilage, and is in contact with the synovial membrane. The ligament is further attached to the aponeurosis covering the Popliteus muscle, and to the oblique fibres of the ligament of Winslow.

Rupture of the internal lateral ligament with displacement of the semilunar cartilages is instanced in the following case recorded by Adams.[1] A man aged thirty-two while in the sitting position received a blow upon the inner part of the knee. Forced abduction followed with undue mobility. An abnormal interval measuring three-fourths of an inch in width existed between the extremity of the femur and the head of the tibia. Recovery was secured with a good limb.

The Interarticular Cartilages (semilunar cartilages

[1] Lancet, 1859, 155.

[1] Med. Times and Gaz., 1857, 603.

or disks) are two in number, and are named from their position the *internal* and the *external* cartilage. They are wide and thick without, but thin and compressed within, and apparently belong to the tibia to the plane of whose articular surfaces they correspond. The lower surfaces are flat, while the upper are concave for the reception of the femoral condyles. Each cartilage covers one-third of the tibial articular surface, to the border of which it is fixed by short fibrous bands, which collectively receive the name of the *coronary ligament.* The *internal cartilage* is of a semilunar figure, narrow and pointed in front, and to a moderate degree fixed to the anterior border of the anterior tibial concavity. It passes backward to be attached to the inner side of the intercondyloid notch. The ends of the cartilage are separated by the entire breadth of the tibial surface. The internal cartilage is in marked contrast to the external, since it sends off no fibres to the crucial ligament. The *external cartilage* is more circular in form than the internal, and is grooved upon its outer side by the tendon of the Popliteus muscle. It is attached in front to the depression in advance of the spine of the tibia, and behind, for the most part, to the space between the two tubercles of the spine of the tibia. The anterior and the posterior ends of this cartilage are of the same size, and are so near each other as to lie within the curve of the internal cartilage, which thus corresponds to the arc of a larger circle than the one described by the external. Small bundles of fibres pass from the external cartilage to the crucial ligament.

The Transverse Ligament is a narrow band of fibres stretching across between the anterior extremities of the interarticular cartilages.

The Crucial Ligaments, or crossing ligaments, are broad though short bands, two in number, and named from their position the anterior and the posterior, extending from the space before and behind the spine of the tibia to the posterior condyloid notch of the femur. The two in crossing describe a figure resembling the letter X, and form a kind of partition between the right and the left sides of the joint. Both ligaments are connected with the external interarticular cartilage.

The *anterior crucial ligament* is attached anteriorly to the inner side of the depression in front of the spine of the tibia. It lies in front of the external interarticular disk, with which it is in part blended. It increases in breadth as it passes upward and outward, and is attached above to the inner and hinder part of the inner surface of the external condyle. The *posterior crucial ligament* is broader and stouter than the anterior, and is attached below to the depression behind the spine of the tibia. Gaining a slight accession from the external interarticular cartilage, it passes upward and a little outward to be attached to the posterior condyloid femoral notch (which it for the most part occupies) as well as by a few fibres to the outer side of the inner condyle.

The crucial ligaments may be ruptured by violence. Mr. Poland[1] records a case of a man forty years of age who incurred an injury of the right knee by a sack of wheat falling upon the thigh of the corresponding side. Amputation was found to be necessary, owing to rupture of the popliteal artery. Examination of the knee demonstrated rupture of the anterior crucial ligament.

The Synovial Membrane is more extended than any other in the body. In addition to lining the capsular ligament, and covering the articular surfaces of the bones entering into the joint, it is reflected from the fat lying between the ligamentum patellæ and the space in front of the head of the tibia; surrounds the crucial ligaments and the tendon of the Popliteus muscle; is reflected upon the interarticular cartilages, and is in contact with the internal lateral ligament at the inner condyle of the femur. The membrane conforms, as a rule, to the shape of the capsular ligament, but above it extends as a *cul-de-sac* beneath the tendon of the Quadriceps Extensor muscle to the distance of several inches. Below to its outer side (and guarded by the tendon of the Popliteus muscle) it sends a prolongation backward and outward upon

[1] Med. Times and Gazette, 1866, 6.

EXPLANATION OF PLATE XLI.

Fig. 1. The hip-joint, seen from in front.

Fig. 2. The knee-joint, seen from behind, showing capsule.

Fig. 3. The knee-joint, seen from the median side

Fig. 4. The knee-joint, seen from behind, showing position of the disks and the crucial ligaments. The names "Internal Condyle" and "External Condyle" should be transposed.

PLATE XLI

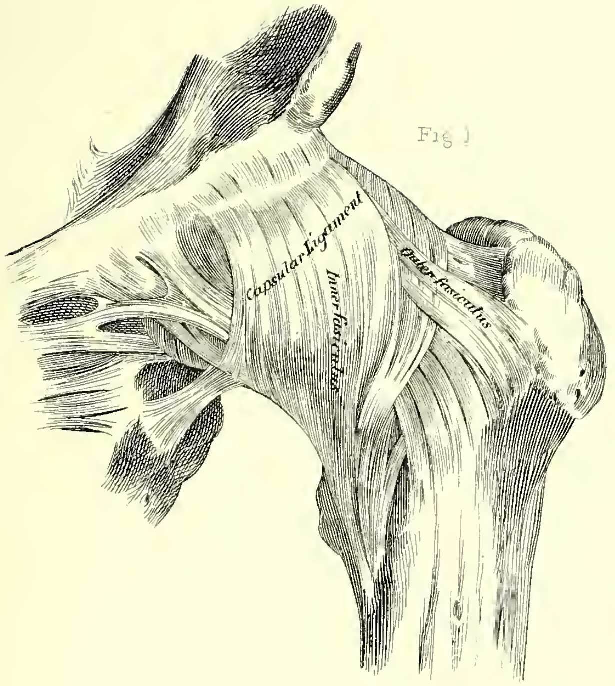


Fig. 1

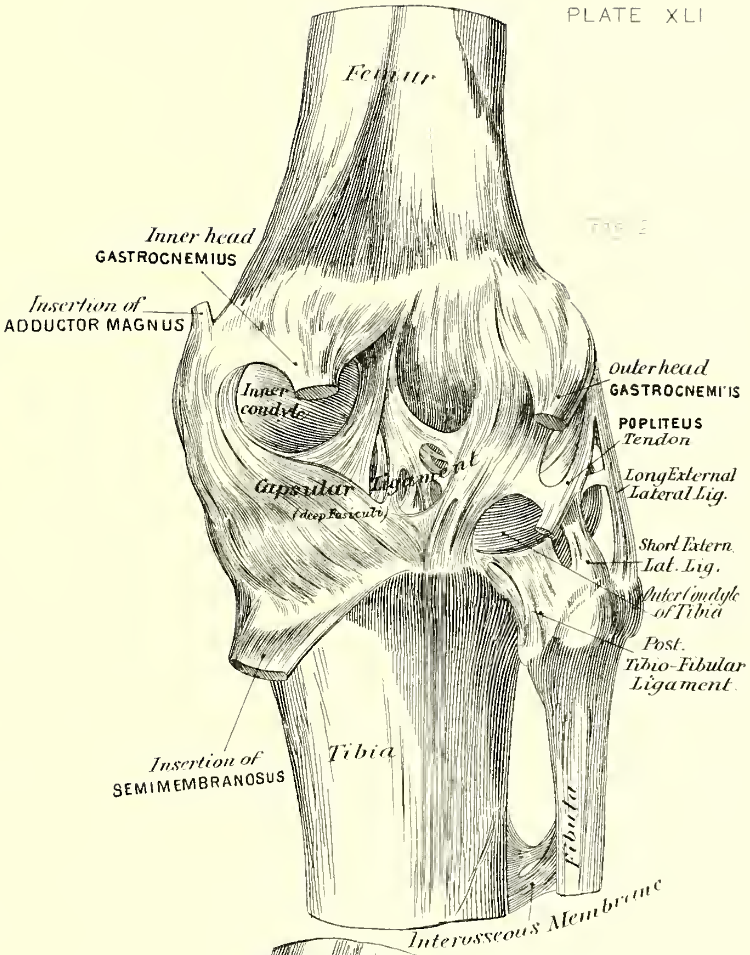


Fig. 2

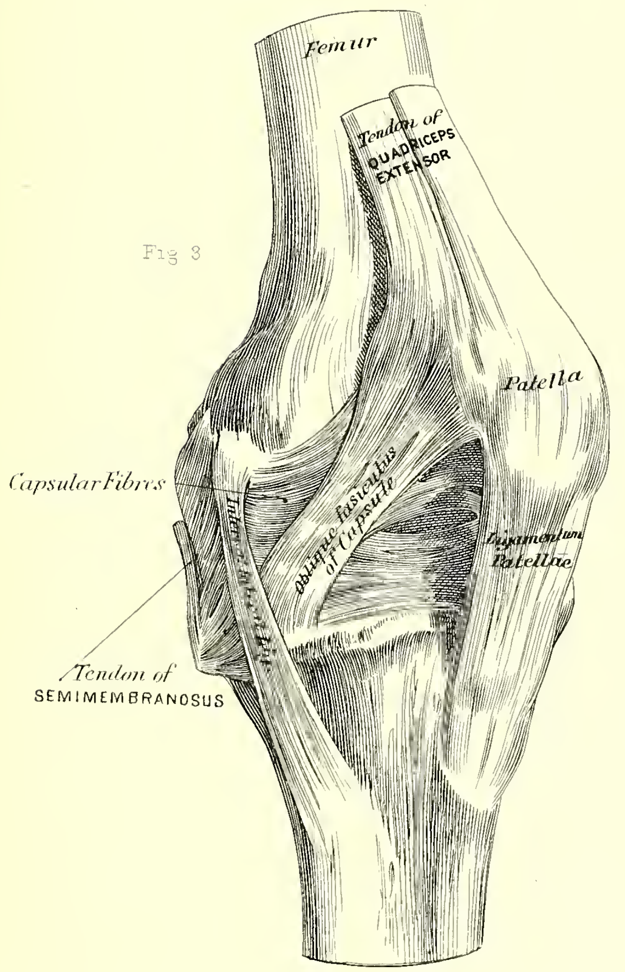


Fig. 3

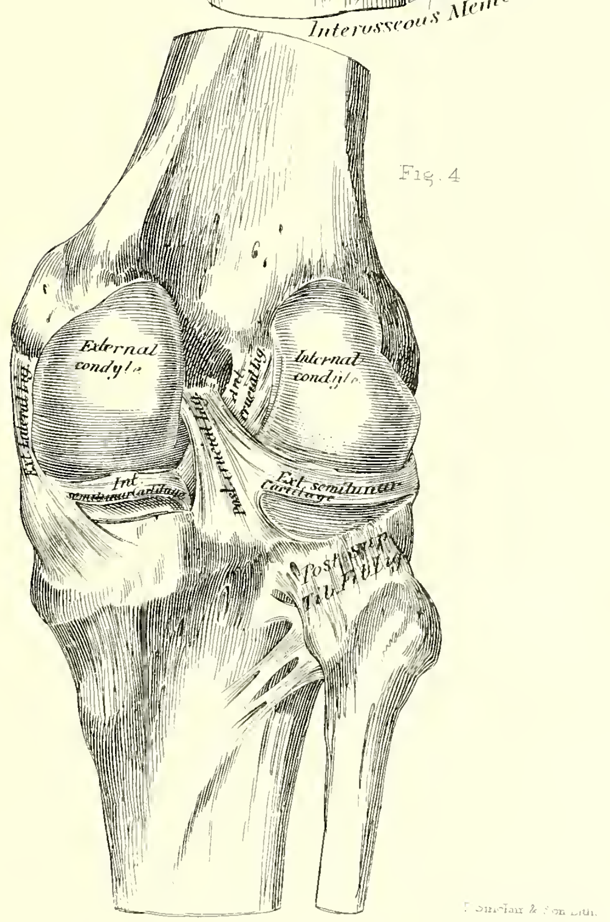


Fig. 4

T. Sinclair & Son Lith.

the outer border of the external interarticular cartilage toward the tibio-fibular articulation, with which it communicates, it is estimated, in one out of every six cases. Behind it passes between the femoral condyles and the origins of the Gastrocnemius muscle. Synovial fringes are present at the lower and front part of the joint, and are especially conspicuous about the lateral margins of the patella and the interarticular cartilages to constitute the two *alar ligaments*, so called. These, beginning at the front and at the sides of the joint below, unite in a rounded cord containing a few ligamentous fibres, and are prolonged backward and upward to the front of the upper condyloid notch.

Beneath the synovial membrane at the sides of the patella, and in front of the femur, a quantity of fat is deposited.

When the knee is extended, the top of the *cul-de sac* lies two inches above the upper margin of the patella. In the flexed position it is lower. Inferiorly the synovial membrane lies a little above the level of the upper part of the head of the fibula.

Cysts forming in the ham are liable to be fixed to the inner tendon of the Gastrocnemius (five cases in twenty); when situated in the middle of the ham there may be hernial protrusions of the synovial membrane of the knee-joint through the posterior portion of capsules (six cases in twenty). They are frequently complicated with hydrarthrosis.[1]

The form of the capsule can be often made out in some of the forms of distension with synovial effusion. Thus the swelling is apt to be rounded and uniform at the inner side of the joint, while inconspicuous and irregular on the outer side. The patellar *cul-de-sac* may be measurably separated from the rest of the joint, and the prolongation about the tendon of the Popliteus muscle may be completely separated from the main cavity of the joint.

Movements.—The movements of the knee-joint are both gliding and rolling. The gliding occurs between the external condyle of the femur and the external interarticular disk, and between the posterior half of the internal condyle and the internal articular disk, as well as at the patellar groove between the patella and the outer condyle. The rolling takes place between the interarticular disks and the tibial condyles, especially at the outer half of the joint and between the narrow oblique facet interpolated between the internal condyle and the patellar groove, which has received the name of the *oblique facet of Meyer*.

[1] Foucher, Archiv. de Médecine, 1856.

Without the aid of the interarticular disks none of the above motions can be effected. The disks convert the sinuate or flat tibial surfaces into shallow cavities admirably adapted to serve as sockets for the femoral condyles. The differences in the shapes of the condyles as contrasted with those of the interarticular disks indicate that the lines of action of each of the condyles are distinct. Flexion and extension, which are in this sense equivalent to the action of gliding, are more complete in the outer than in the inner half of the joint. In this connection it is well to remember the less fixed and more rounded form of the outer disk as compared with that of the inner, and the decided manner in which the ligaments check the extremes of motion. The longer external lateral ligament, for example, is a well-defined cord-like band of great strength placed further back than is the internal lateral ligament. It is, therefore, of the two the more thoroughly relaxed, while in extension the same ligament is made proportionally more tense. As the joint is flexed, a disposition exists for the tibia to rotate upon its longitudinal axis. This movement takes place, it is thought, between the external femoral condyle and the external disk acting as one factor, and the outer tibial condyle as the other. Meyer estimates that the degree of rotation here effected is in direct ratio to the angle of flexion of the limb at the knee, when it is seen of necessity to be dependent upon the extent to which the ligaments of the external condyle have become relaxed. Flexion of the outer half of the joint is limited by the anterior crucial ligament which becomes tense in extreme flexion, while extension is limited by the posterior crucial ligament. In moderate degrees of flexion, namely, those that most likely occur in the acts of walking, sitting, etc., the anterior crucial ligament is relaxed.

In flexion of the inner half of the knee the movement is seen to be guarded by the weaker and fascia-like internal lateral ligament which is placed well forward, as also by the broad bands accessory to the capsule at this place. The posterior crucial ligament assists the internal lateral ligament in keeping the inner condyle in position, but the last-named, as has already been seen, is less relaxed in flexion.

The rotatory movement at the inner side of the joint is also much less pronounced than at the outer. On the other hand, the rolling motion between the internal disk and the inner femoral condyle at the oblique facet is increased, and a peculiar curve upward and inward is described, that has been compared to the figure of the spiral, hence the name of screw-motion

that Meyer has given to it. This movement of the knee is seen, it is thought, in the act of raising the leg and bringing it over the thigh of the opposite side. Rotatory movements of the knee are limited by the crucial and the capsular ligaments.

Extremes of flexion and extension are liable to be followed by rupture. The lesions of this class have been formulated by L. Dittel[1] as the result of experiments upon the dead body. This observer, by forcibly flexing the knee in a specimen prepared by removal of the muscles, found that the *anterior* crucial ligament ruptured at its femoral attachment. By placing the knee of a similarly prepared limb over the interval between two blocks, a violent blow with a mallet (thus imitating the force of hyper-extension) caused in some instances rupture of the *posterior* crucial ligament at its femoral attachment.—In another series of experiments a strong man placed the lower extremity of the subject over his shoulder with the posterior surface of the knee upward, and induced hyper-extension of the knee by forcibly dragging the leg downward. This experiment performed upon a young individual separated the tibial epiphysis posteriorly, the ligaments remaining for the most part uninjured; upon old individuals the femoral condyles irregularly fractured the tibial articular surfaces, the ligaments, as before, being preserved intact. If in the latter experiment the leg was carried at a right angle to the femur, both crucial ligaments were found ruptured,—the anterior at its femoral, the posterior at its tibial attachment.—In forced abduction of the extended joint the internal lateral ligament was found ruptured in the middle, or at the tibial or femoral end. In forced adduction similar lesions occurred in the external lateral ligament.

Movement outward is checked by a band of the capsule which has received the name of the *lateral accessory ligament* of Henle, while movement inward is checked by an analogous band on the median side of the joint called the *median accessory ligament* of Henle. Rotations in the extremes of extension and flexion are checked by the crucial ligaments, particularly by the anterior.

The knee, while thus seen to be capable of extreme flexion, does not possess this function so exactly as does the elbow joint, with which of all the joints the knee can be most advantageously compared. In the elbow, for example, the Brachialis Anticus lies upon the flexor aspect, and determines an exact line of bending. No similar muscle is situated upon the flexor surface of the knee. The flexors instead are placed at the sides, and are therefore modified flexors only, since they not only flex, but incline the limb toward the side where the bending forces are the strongest.

The knee is further assisted in maintaining the apposition of its several parts by the fascia lata, especially that portion which lies in direct line with the Tensor Vaginæ Femoris muscle.[1]

Nerves.—The knee-joint receives upon its anterior surface a branch of the long saphenous nerve; upon its external and anterior surface a branch of the peroneal nerve (this twig lies in company with an articular artery); externally and posteriorly by a twig of the anterior tibial nerve; internally (medianly) by a twig from the posterior tibial nerve; externally by a recurrent branch of the deep branch of the peroneal nerve, while the interior of the joint through the posterior crucial ligament receives a branch of the posterior tibial nerve.[2]

The Tibio-fibular Articulations.

The tibia and the fibula are joined (fig. 1, Plate XLII.) by two simple articulations called from their positions the superior and the inferior tibio-fibular joints.

The superior tibio-fibular joint surfaces are oval in form, nearly flat, and obliquely disposed. The tibial surface is the larger, and looks downward and outward. The synovial membrane is rather loose, and occasionally communicates with the sheath of the Popliteus muscle, and thence with the knee-joint. The tendon of the Biceps Femoris muscle is of equal value with the ligaments in maintaining the apposition between the facets of the joint.

The superior ligaments are two in number—

The Superior Anterior Tibio-Fibular Ligament.

The Superior Posterior Tibio-Fibular Ligament.

The Superior Anterior Tibio-Fibular Ligament is attached in front to the external condyle of the tibia, and passes downward and outward to be attached behind to the head of the fibula.

The Superior Posterior Tibio-Fibular Ligament is a single thick, short band extending from the tibia at the lower border of the groove for the tendon of the Popliteus muscle to the head of the fibula. It is covered by the last-named muscle.

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[1] Stricker's Med. Jahrbucher, 1876, 319.

[1] For additional literature upon lesions of the ligaments, etc., of the knee, see A. Bruce, Trans. Path. Soc., London, vol. xviii.—Guy's Hosp. Reports, 1867. Lancet, 1859, ii. 240.

[2] H. Meyer, Virchow's Archiv., vol. xii. 124, 1857.

The inferior ligaments are three in number—

The Inferior Anterior Tibio-Fibular Ligament.

The Inferior Posterior Tibio-Fibular Ligament.

The Inferior Interosseous Membrane.

The Inferior Anterior Tibio-Fibular Ligament is of a triangular shape, and is attached to the anterior border of the tibia just above the surface articulating with the astragalus. It passes obliquely downward and outward to the anterior part of the external malleolus. This ligament projects a short distance, viz., about two lines beyond the articular surfaces it serves to unite. It is here covered with cartilage, and is continuous with the ankle-joint. It is sometimes composed of from two to three distinct fasciculi.

The Inferior Posterior Tibio-Fibular Ligament is shorter than the anterior. It passes from the tibia downward and outward to be fixed at the internal border of the groove upon the posterior part of the external malleolus. Both of the inferior ligaments are of great strength, and serve not only to sustain the fibula in apposition to the distal end of the tibia, but to assist the proximal end as well.

The Inferior Interosseous Ligament is triangular in form, with its base directed downward. Its oblique fibres intimately unite the tibia and the fibula between their contiguous surfaces at the lower three-fifths of their shafts. It is continuous above with the interosseous membrane. The small synovial surface is continuous with the ankle-joint.

The tibia and the fibula in addition to the above joints are connected by the interosseous membrane.

The Interosseous Membrane.

The Interosseous Membrane (superior interosseous ligament) (fig. 1, Plate XLII.) passes between the external border of the tibia and the external ridge of the fibula. It is broader above than below, but does not entirely occupy the interosseous space. The deficiency at the upper part of the space permits the passage of the anterior tibial artery, while the one below accommodates the peroneal artery and vein in their passage from behind forward.

Remarks.—The movements of the superior articulation are much freer than those of the inferior. The lateral motion of the fibula against the tibia is greater than the disto-proximal motion. The latter, indeed, is of necessity slight, owing to the overlapping of the tibial condyle at the superior fibular facet, the shortness of the fibres of the inferior group of ligaments, and the strength of the middle external lateral fascicle.

Nerves. The superior tibio-fibular joint receives its nervous supply posteriorly from a twig from the posterior tibial nerve as it supplies the Popliteus muscle, and anteriorly from a recurrent branch from the peroneal nerve.

The Ankle-Joint.

The parts entering into the ankle-joint (fig. 1, 4, Plate XLII.) are the tibia, the fibula, and the astragalus. The union of the tibia and fibula forms a sort of arch or mortise having a greater breadth from side to side than from before backward to receive the proximal surface of the astragalus.

The antero-posterior curve in the last-named surface is greater than that derived from the tibia and the fibula, so that all of the astragalar surface is not in contact with the mortise at one time. The posterior end being about one-sixth smaller than the anterior, it follows that the lateral borders slightly diverge from before backward. In addition to this the sides of the astragalar surface are abrupt. The inner, the shorter of the two, is inclined somewhat outward; the outer is abruptly deflected outward at its lower end; the external malleolus may thus impinge upon the astragalus when the trunk is in the erect position.

The posterior portion of the superior astragalar surface exhibits a distinctive facet for articulation with the surface of the inferior interosseous ligament entering into the joint.

The ankle-joint is composed of—

The Internal Lateral Ligament.

The External Lateral Ligament.

The Synovial Membrane.

The Internal Lateral Ligament (deltoid ligament), the stoutest of the ligaments of the ankle-joint, is a broad, coarsely fasciculated structure attached above to the internal malleolus, and below, by a broad line, to the astragalus, the calcaneum, and the scaphoid bone. It consists of two layers—a superficial and deep. The *superficial* and larger layer is attached above to the apex and the sides of the malleolus, and below to the points already mentioned. The *deep* layer is much shorter than the superficial. It passes downward and backward to connect the deep portion of the internal malleolus with the astragalus.

The superficial layer is divided into two more or less distinct anterior and posterior fasciculi. The *anterior fasciculus* is thinner than the posterior. It is attached above to the anterior border of the internal malleolus, and below to the inferior calcaneo-sca-

phoid ligament and the scaphoid bone. It extends the length of the median border of this ligament.—The *posterior fasciculus*, somewhat rectangular in shape, is attached above to the inferior surface of the superior aspect of the internal malleolus, and below to the astragalus and the calcaneum.

The internal lateral ligament protects the surface of contact with the internal malleolus in all its motions.

The External Lateral Ligament, conventionally so called, is composed of three distinct ligaments, named, from their relative positions, the anterior, the middle, and the posterior fascicles.—The *anterior fascicle*, the shortest of the three, is attached above to the anterior border of the external malleolus; it passes almost horizontally forward and inward to be attached to the astragalus at the junction of the neck and the body. It often splits into two bundles. In flexion it touches the anterior tibio-fibular ligament.—The *middle fascicle*, the longest of the three, is also the strongest. It assumes the form of a rounded cord, which is fixed above to the fibula directly in front of the apex of the external malleolus, and below to the external surface of the calcaneum.—The *posterior fascicle*, the weakest of the three, and more deeply situated than the others, passes nearly horizontally inward from a groove on the inner side of the external malleolus to the posterior surface of the astragalus on the groove between the upper and the lower articular surfaces. In extension of the ankle-joint this ligament touches the lower border of the posterior inferior tibio-fibular ligament.

No capsule, properly speaking, exists at the ankle-joint. The joint is protected in front and behind by dispositions of fibres having little strength. The fibres of the posterior set have the same general arrangement as those of the ligament last named.

The Synovial Membrane is unyielding on the sides where it answers to the malleoli, and where it lies in contact with the ligaments of the ankle and those of the inferior tibio-fibular joint, but is relaxed and loose both in front and behind to such a degree as to permit, during flexion and extension, transverse creases or folds to form. Anteriorly the membrane extends a short distance upon the neck of the astragalus, from which it is separated by a small quantity of fat. This prolongation is divided into a number of imperfectly defined compartments by a series of vertically disposed septa. Superiorly the membrane lies between the tibia and the fibula to constitute the inferior tibio-fibular joint, as already seen. The outer surface of the membrane is in association anteriorly with the tendons of the extensors of the toes, and posteriorly with the tendons of the Gastrocnemius and the Plantaris muscles. The tendon of the last-named muscle may be said to exercise a tensile power over the membrane. The synovial fringes which are so conspicuous in the knee-joint are in the ankle absent or insignificant.

Movements.—The movements of the ankle-joint are in the main those of the ginglymoid joints. When the weight of the body is borne directly upon the astragalus, as in *standing erect*, the astragalus acts as a continuation of the shaft of the tibia, and serves to transmit the weight of the body to the arch of the foot. In this position the ligaments are relaxed, and the bone has a disposition to glide forward, since the upper articular surface is narrower behind than in front. This tendency is checked by the interosseous calcaneo-astragalar ligament, and by the impact of the astragalus against the scaphoid and the ligamentous bands uniting the last-named bones to each other and to the bones of the leg.

In *extension*, the anterior fifth of the superior astragalar surface is exposed, as is the corresponding portion of the articular surface for the external malleolus. The movement is checked laterally by the anterior fascicle of the external lateral ligament, which, while becoming tense, assumes a direction obliquely downward and inward; the middle and posterior fascicles are relaxed. The movement is checked medianly by the anterior half of the deltoid ligament, while the posterior half is relaxed.

In *flexion*, the narrowed posterior third of the

EXPLANATION OF PLATE XLII.

Fig. 1. The ankle-joint, seen from behind.

Fig. 2. The dorso-ventral section of the tarsus, showing synovial sacs. For the word "metacarpus" substitute "metatarsus."

Fig. 3. The proximal end of tibia with the interarticular disks in position, and the tibial attachments of the crucial ligaments displayed.

Fig. 4. The ligaments of the foot, seen from the median side.

Fig. 5. The ligaments of the foot, seen from beneath.

PLATE XLII

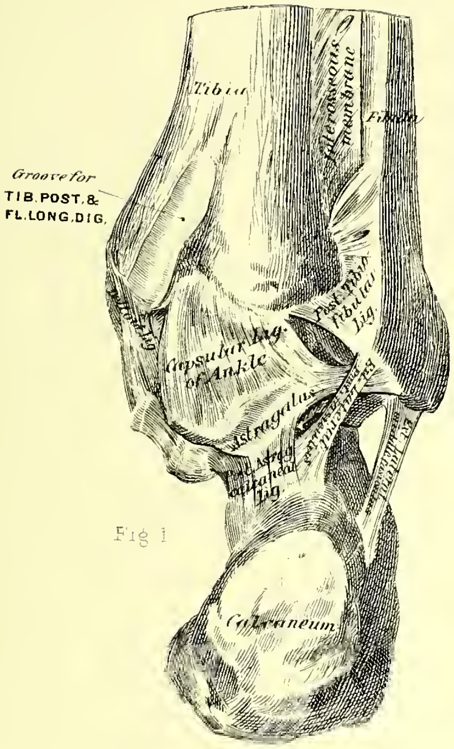

Fig 1

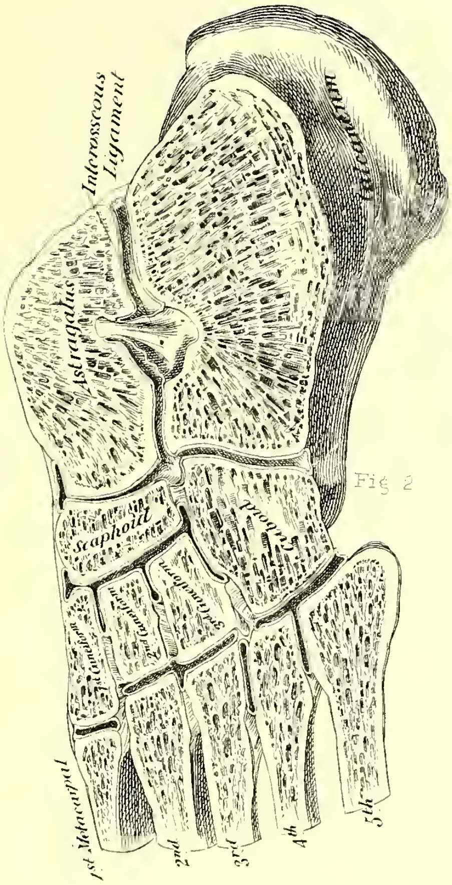

Fig 2

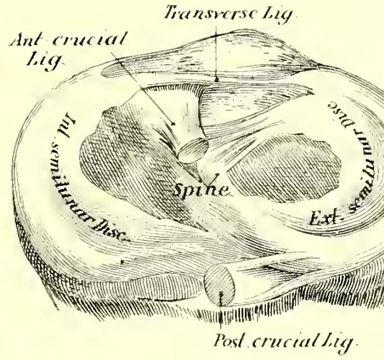

Fig 3

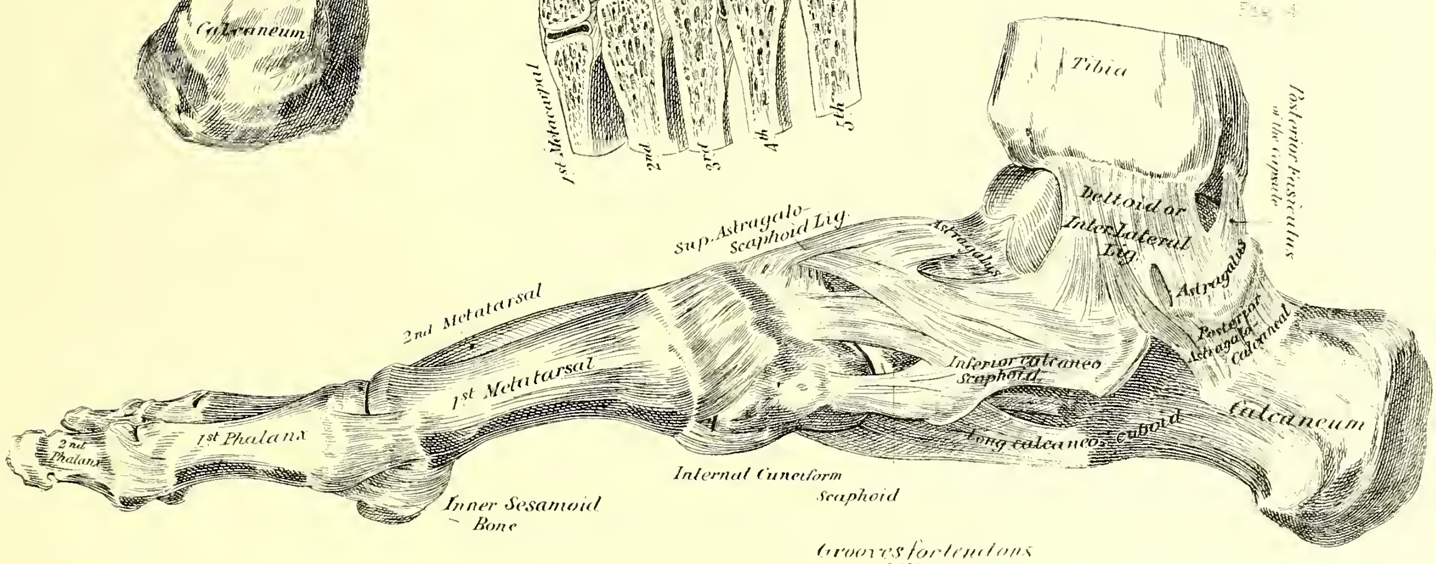

Fig 4

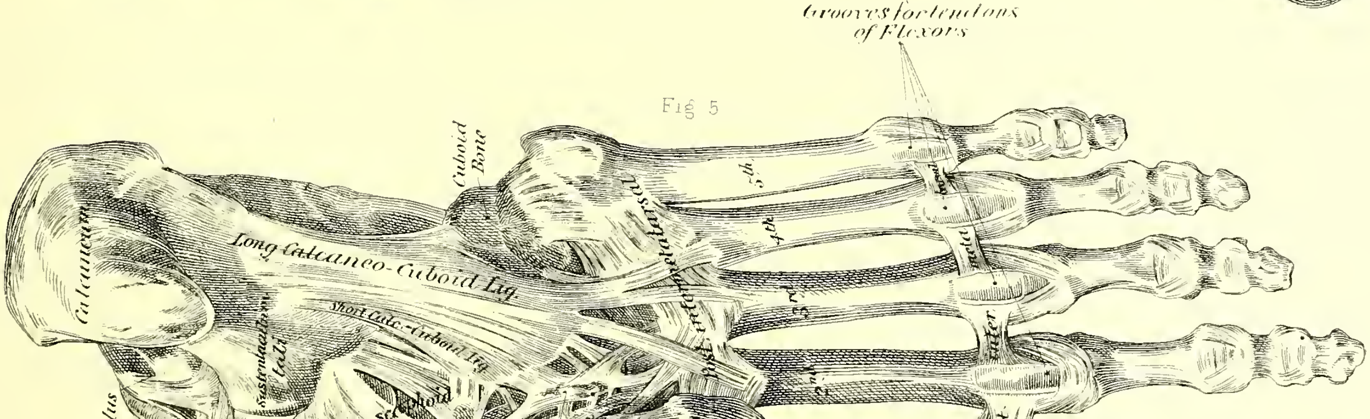

Fig 5

T. Sinclair & Son Lith.

superior articular surface is exposed, including a small portion of the surface of the outer malleolus, while ligaments relaxed in extension are now tense, and those previously tense are now relaxed. The movement is limited by the anterior lip of the tibial surface impinging against the neck of the astragalus. The ankle-joint in flexion is firmly fixed; rotation of the bones of the leg is transmitted to the astragalus; and motion takes place between the astragalus and the calcaneo-scaphoid concavity. In extension a very slight lateral motion is perceptible between the tibia and the astragalus.

The middle fascicle of the external lateral ligament and the analogous band in the internal lateral ligament extending from the bones of the leg to the calcaneum—thus passing over the astragalus—have caused the last-named bone to be held in part as analogous to an interarticular disk between the bones of the leg on the one hand, and the calcaneum and the scaphoid on the other.

It is interesting in this connection to recall the facility with which persons who have lost the astragalus by excision of this bone after dislocation may yet walk with comparative ease. In such examples the distal ends of the bones of the leg move upon the calcaneo-scaphoid socket after the fashion of the head of the astragalus.

In birds the astragalus is permanently anchylosed to the tibia, so that all the motions between the leg and the foot are such as occur in the human subject in flexion of the ankle between the leg and astragalus as one factor, and the remaining tarsal bones as the other.

The attachments of the ligaments of the ankle-joint are so strong that severe wrenchings will more often result in the separation of the osseous surfaces in connection with the fibres of the ligaments than in rupture of the ligaments themselves. Mr. Callender, who first called attention to this subject, justly believes that the occurrence of such violence to the living bone is an efficient cause in prolonging the reparation of injuries incident to a severely sprained ankle.

In Pott's fracture, in which the fibula is fractured at the lower third, the ankle-joint is of necessity impaired in its functions. The ginglymoid character of the joint is destroyed by the separation of the external malleolar surface from the astragalus. Dr. W. W. Keen has observed that in this fracture the astragalus can be pushed away from its contact against the internal malleolus with ease.

In *talipes equinus* the anterior portions of the lateral ligaments are lengthened, while the posterior are shortened.

Rarely a bursa, lying beneath the internal lateral ligament, communicates with this joint, or with the joint between the head of the astragalus and the scaphoid bone and the calcaneum.

Nerves.—The ankle receives posteriorly a nerve from the posterior tibial nerve, anteriorly one from the anterior tibial.

Arteries.—These are derived from the malleolar branches of the anterior tibial and the peroneal arteries.

The Joints and Ligaments of the Foot.

The bones of the foot are adapted to one another by concave, convex, or flat surfaces, and are held together by ligaments of great strength and variety.

When the weight of the body is borne by the foot, the astragalus is fixed between the malleoli, and functionally acts in this position as a continuation of the tibia in transferring the weight to the remaining tarsal bones.

As a result of this weight there is a disposition on the part of the bones of the tarsus to be pressed downward, the arches of the foot to be destroyed, and the metatarsal bones to spread laterally. Both joint-surfaces and the ligaments tend by their disposition to overcome this tendency, which is still further resisted by the lines of traction of muscles.

The ligaments are all stouter and more varied on the plantar surface and in the interosseous spaces than on the dorsal surface.

The following classification will be followed in this connection:—

The Joints and Ligaments of the Tarsus.

The Joints and Ligaments between the Tarsus and the Metatarsus.

The Inter-Metatarsal Joints and Ligaments.

The Joints and Ligaments between the Metatarsus and the Phalanges.

The Inter-Phalangeal Joints and Ligaments.

THE JOINTS AND LIGAMENTS OF THE TARSUS.

The joints of the tarsus (figs. 2, 8, 5, Plate XLII.) are the following:—

The joint between the astragalus and the calcaneum posterior to the interosseous ligament. It possesses a separate synovial membrane and capsule.

The joint between the astragalus, and the calcaneum in advance of the interosseous ligament, together with

the scaphoid bone and the inferior calcaneo-scaphoid ligament. This extensive and important surface is inclosed by a common synovial membrane.

The joint between the calcaneum and the cuboid bone.

The joint between the scaphoid bone and the three cuneiforms is concave proximally and convex distally. The lateral facets between the cuneiform bones and the cuboid are sufficiently indicated in the description of these bones.

The chief ligaments of the tarsus are—

The External Astragalo-Calcaneal.
The Internal Astragalo-Calcaneal.
The Interosseous.
The Superior Calcaneo-Cuboid.
The Internal Calcaneo-Cuboid.
The Inferior Calcaneo-Cuboid.
The Superior Calcaneo-Scaphoid.
The Inferior Calcaneo-Scaphoid.
The Astragalo-Scaphoid.
The Scaphoido-Cuneiform.
The Scaphoido-Cuboid.

The External Astragalo-Calcaneal Ligament.—This is a small fasciculus attached above to the astragalus, and below is inserted into the calcaneum alongside of the middle fasciculus of the external lateral ligament of the ankle-joint, with which it is often in part confounded.

The Internal Astragalo-Calcaneal Ligament is short, slender, and membranous, and is attached above to the astragalus at the border of the groove for the Flexor Longus Pollicis, and below to the calcaneum.

The Interosseous Ligament (middle astragalo-calcaneal).—This powerful structure occupies the canal between the astragalus and the calcaneum. It is narrow and short medianly, but widens as it approaches the lateral aspect of the foot, where it is superficial. As displayed within the sinus tarsi, the ligament is divided into two portions by a wide interval. The *posterior portion* (posterior interosseous) is a thin but stout fascicle that serves to strengthen the posterior of the two astragalo calcaneal joints. The *anterior portion* (anterior interosseous) is coarser and stouter than the preceding, and unites the superior portion of the anterior process of the calcaneum to a roughened surface on the neck of the astragalus.

The Superior Calcaneo-Cuboid Ligament is a flat band extending from the upper and outer portion of the anterior border of the calcaneum to the corresponding part of the cuboid bone. It is entirely dorsal, and lies to the outer side of the Superior Calcaneo-Scaphoid ligament.

The Internal Calcaneo-Cuboid Ligament (interosseous) is a flat band of great strength attached proximally to the calcaneum, at the sinus tarsi directly within the anterior portion of the interosseous ligament. Distally it is attached to the cuboid bone at the interval between the proximal and the median surfaces. As a rule it is united at its calcaneal attachment with the Interosseous ligament, the two bands forming a V-shaped figure.

The Inferior Calcaneo-Cuboid Ligament is the stoutest and largest ligament of the foot. It is composed of two separate fasciculi or bundles of fibres, which may be known as the greater and the lesser ligament. The *greater ligament*, thicker medianly than laterally, is attached proximally to the entire length of the under surface of the calcaneum in advance of the tubercles. It extends forward in a straight line, and is attached distally to the under surface of the cuboid bone at the tubercle as far as the groove for the tendon of the Peroneus Longus muscle. The ligament strengthens the sheath of the last-named muscle, and sends prolongations to the bases of the fourth and fifth metatarsal bones.—The *lesser ligament* is attached distally to the anterior tubercle of the calcaneum, passes obliquely forward and inward, and is concealed in part by the greater ligament, to be attached to the cuboid bone at the proximo-median angle.

The Superior Calcaneo Scaphoid Ligament (external calcaneo-scaphoid, interosseous) extends from the anterior portion of the calcaneum at the place of origin of the internal calcaneo-cuboid ligament. It is a stout, flat, well-defined band—its superior border lying on the dorsal, and its inferior on the plantar surface—and extends obliquely forward and inward, to be attached to the outer side of the scaphoid bone. Inferiorly it is in contact with the small cartilaginous surface at the medio-plantar angle of the cuboid bone.

The Inferior Calcaneo-Scaphoid Ligament extends as a broad, somewhat radiated structure from the median surface of the calcaneum at the interval between the anterior tubercle and the *sustentaculum tali*, as well as the median borders of the facet of articulation with the astragalus. It passes forward and inward to be attached to the under surface of the scaphoid bone. Its fibres are continuous proximally with those of the deltoid ligament, and distally in part with the cuboidal attachment of the lesser calcaneo-cuboidal ligament. At its upper portion it is thicker than elsewhere, and depressed for the accommodation of the tendon of the Tibialis Posticus muscle which strengthens the ligament, and indirectly supports the

head of the astragalus. Viewed from above, in a foot from which the astragalus has been removed, the inferior calcaneo-scaphoid ligament is seen to form the median and basal aspect of a socket of which the calcaneum and the scaphoid bone form the remaining parts. The ligament is of great strength, and aids in breaking the shock attending the abrupt transfer of the weight of the body through the astragalus upon the foot.

The Astragalo-Scaphoid Ligament is a broad, fine-textured, capsule-like membrane extending from the dorsum of the neck of the astragalus forward over the prominence of the head of the same bone to the dorsum of the scaphoid bone, some of its fibres passing to the second cuneiform. It partly overlies the scaphoido-cuneiform ligaments.

The Scaphoido-Cuneiform ligaments superiorly are distinct flat slips passing from the scaphoid bone to the cuneiform bones. They are best developed on the median border of the foot when the scaphoid and the first cuneiform bone are united. Inferiorly the single stout scaphoido-cuneiform ligament is attached proximally to the tubercle of the scaphoid, and passes in a radiate manner thence to the cuneiform bones.

The Scaphoido-Cuboidal Ligaments present a superior, an inferior, and an interosseous fascicle. The *superior fascicle* is much shorter than the inferior. It passes from the upper and the median part of the superior surface of the cuboid to the scaphoid bone. The *inferior fascicle*—one of the most conspicuous of the plantar ligaments—passes in the form of a flattened cord from the tuberosity of the scaphoid bone forward and outward to the cuboid bone. The *interosseous fascicle* occupies the deep excavation between the scaphoid and the cuboid bones, and is also attached to the third cuneiform.

The three cuneiform bones are held together by short, peripheral, and interosseous ligamentous bands, as in the union of the third cuneiform with the cuboid. They do not demand extended description.

Remarks.—The actions of the ligaments of the tarsus can be best studied by dividing them under the following heads:—

(1) The movement of the astragalus on the calcaneum and the scaphoid bone.

(2) The movement of the calcaneum on the cuboid.

(3) The movement of the medio-tarsal joint.

(1) The weight of the body when thrown upon the foot tends to rotate the astragalus on the fixed calcaneum inward; the head of the first-named bone moves inward and downward on the line of motion afforded by the posterior calcaneo-astragalar articulation. The action is checked by all the ligaments of the ankle-joint, the astragalo-calcaneal, the anterior portion of the interosseous (now horizontal), the superior and the inferior calcaneo-scaphoid which become tense. The astragalo-scaphoid ligament and the posterior portion of the interosseous ligament are relaxed.

When the weight of the body is removed from the foot, as in the supine position, the posterior calcaneo-astragalar articulation is at rest, and the surfaces in part separated. The posterior portion of the interosseous ligament and the astragalo-scaphoid are tense, while the remaining ligaments are relaxed. The head of the astragalus at the same time forms a prominence on the dorsum of the foot.

In the affection ordinarily called "sprained ankle" the ligaments of the ankle and the tarsal ligaments, save two only, are subjected to over-strain. The posterior calcaneo-scaphoid joint suffers more than any other portion of the tarsus, and develops an exquisitely tender spot answering to pressure over the sinus tarsi. Should the ligaments holding the astragalus to the calcaneum and the calcaneum to the scaphoid bone yield, dislocation of the astragalus forward and inward is effected.

(2) When the weight of the body is borne on the foot, as in the erect position, the nearly flat joint between the calcaneum and the cuboid bone becomes entirely engaged. The inferior calcaneo-cuboid ligament becomes tense, while the superior ligaments become relaxed.—In the supine position the joint is at rest, and the surfaces tend to separate from one another. The inferior ligament is now relaxed, and the superior is tense. The astragalo-scaphoid, and both the dorsal calcaneo-cuboid ligaments might now be termed suspensory to the foot beyond the medio-tarsal line.—The prolonged retention of the foot in the position last described constitutes "foot-drop," a complication which is liable to occur in bed-ridden patients when the foot is kept for a long time without support to the medio-tarsal joint. *Talipes equinus* is a variety of "foot-drop."

(3) The action of the medio-tarsal joint is one of torsion about the internal calcaneo-cuboid and the calcaneo-scaphoid ligaments. The torsion is determined by muscles inserted distally to the joint-line. The Tibialis Anticus and the Tibialis Posticus act on the stout median border from the inner side, and turn the sole downward and inward, while the Peroneus Longus, acting on the same line from the outer side, turns the sole downward and outward.—Inward rotation of the astragalus tends to carry the foot inward—an action antagonized by the Peroneus Longus.

When this muscle contracts, while the weight of the body is borne upon the foot, the check ligaments to the motion of the astragalus are made more tense.—The line of motion in torsion is determined at the medio-tarsal joint. When outward torsion is effected without weight being thrown on the foot, the foot is said to be *pronated.* In *talipes valgus* the pronation is extreme and persistent. In pronation the motion is checked by the superior calcaneo-scaphoid and astragalo-scaphoid ligaments. In females pronation is more pronounced than in males. In the motion opposite to the above the foot is said to be *supinated.* The superior calcaneo-scaphoid ligament is relaxed, and the internal calcaneo-cuboid is tense. Supination is the congenital position of the foot. Extreme and fixed supination constitutes *talipes varus.*

The medio-tarsal joint corresponds to nearly a transverse line, so that the foot can here be easily disarticulated.

THE JOINTS AND THE LIGAMENTS BETWEEN THE TARSUS AND THE METATARSUS.

The joints between the tarsus and the metatarsus are three in number :—

One between the first cuneiform bone and the corresponding metatarsal bone. It is convex proximally, concave distally, and longer from the dorsal to the plantar surface than from side to side.

One between the second and the third cuneiform bones and the corresponding metatarsal bones. It is slightly convex proximally, concave distally at its median, but nearly flat at its lateral half.

One between the cuboid bones and the fourth and fifth metatarsal bones. It is concave proximally and convex distally.

Each of the above joints is furnished with a separate synovial sac. The synovial membranes of the tarso-metatarsal articulation are arranged as follows: one sac intervenes between the first cuneiform bone and the corresponding metatarsal bone. The second is a large sac between the second and the third cuneiform bones and the cuboid above, and the outer four metatarsal bones below, between the heads of which it may send small prolongations.

The middle and external cuneiform, and the second and third metatarsal bones may possess a sac separate from that between the cuboid and the outer two metatarsal bones, as seen in fig. 2, Plate XLII.

The ligaments between the tarsus and the metatarsus are—

The Superior Ligaments.
The Inferior Ligaments.
The Interosseous Ligaments.

The Superior (dorsal) Ligaments are seven in number. The most internal of these unites the first cuneiform bone to the first metatarsal. The three following unite the first, the second, and the third cuneiform bone to the second metatarsal bone; a separate ligament passes from the third cuneiform bone to the third metatarsal. Fascicles pass from the cuboid bone to the fourth and the fifth metatarsal bones.

The Inferior (plantar) Ligaments. The crowded condition of the narrowed inferior borders of the second and the third cuneiform bones, together with the corresponding border of the cuboid, renders the inferior ligament less regular than the superior, but it follows the rule of the ligaments of the foot elsewhere in being more powerful. Those uniting the relatively enormous surfaces of the first cuneiform and the first metatarsal, as well as those of the adjoining bones, are stouter than the remaining ligaments. In addition to the above, bands of variable size pass from the first cuneiform to the second and the third metatarsals. The region is protected by the tendons of the Tibialis Posticus and the Peroneus Longus muscles.

The ligaments passing from between the bones at the cuboid-metatarsal joint are unimportant. The most striking is a band of inconstant size extending between the bases of the third and fourth metatarsal bones under the cuboid bone.

The Interosseous Ligaments are two in number—the internal and the external. The *internal*, the longer of the two, extends from the first cuneiform bone to the opposite side of the second metatarsal close to the articular facet. The *external* extends between the outer side of the third cuneiform bone to the inner side of the fourth metatarsal. A slip of this band also passes to its own metatarsal bone.

THE INTER-METATARSAL JOINTS AND LIGAMENTS.

The metatarsal bones are connected with one another at both the distal and the proximal ends.

The ligaments, as in the case of the tarso-metatarsal, are divided into—

The Superior Ligaments.
The Inferior Ligaments.
The Interosseous Ligaments.
The Transverse Ligaments.

The Superior (dorsal) Ligaments are delicate bands directed transversely. The most internal pass from the first to the second bones; the middle from the

third to the fourth; and the external from the fourth to the fifth.

The Inferior (plantar) Ligaments are stronger than the above-named, but resemble them in their general plan.

The Interosseous Ligaments are placed between the opposed surfaces of the metatarsal bones near the proximal extremities. They are weaker than are the ligaments of the tarsus of the same name.

The Transverse Ligaments are names given to loosely fasciculated bands uniting the distal ends of the metatarsal bones.

THE JOINTS AND LIGAMENTS BETWEEN THE METATARSUS AND THE PHALANGES.

These articulations furnish a convex proximal surface well advanced on the plantar region, and a concave distal surface. In the first joint this surface is as broad as high. The motion of flexion is impaired by the position of the sesamoid bones on the plantar aspect.—The proximal surfaces of the remaining joints are compressed laterally.—Each joint is inclosed by a synovial sac and capsule, which are weaker above than elsewhere, and which are greatly strengthened on the sides by cord-like lateral ligaments passing obliquely downward and forward. They are thick inferiorly where they are supported by the tendons of the flexors of the toes.

THE INTER-PHALANGEAL JOINTS AND LIGAMENTS.

The joint surfaces of these articulations are convex proximally, and concave distally, with the exception of the first inter-phalangeal, where the proximal surface is so far depressed in the centre as to become concave. The joints are well protected on all sides by the synovial sacs and capsules, the latter being strengthened at the sides by the lateral ligaments. Beneath, each joint is supported by a fibrous pad or plate and the underlying tendons of the flexors of the toes. In necrosis of the phalanges, the inferior fibrous pads above mentioned will oftentimes retain the bones in connection with the living parts after all other bands have been destroyed.

Remarks.— The great strength of the first toe enables the ballet-dancer to sustain upon the inter-phalangeal joint the entire weight of the body.—Owing to the disposition of the first metatarso-phalangeal joint, flexion is here imperfectly performed.—This joint is frequently deformed by acquired deflection of the first phalanx outward, and is often the seat of an inflammation communicated to it by a bursa situated above and to its inner side.

The Nerves of the metatarso-phalangeal articulations are derived from the external plantar. Those of the inter-phalangeal joints are derived from the internal plantar.

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